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THE LIMITATIONS OF MATHEMATICAL THEORY APPLIED TO ENGINEERING

By W. G. BUTTON

Read October 4, 1913

Oliver Wendell Holmes, in his "Poet at the Breakfast Table," introduces two characters in strong contrast: the "Master of Arts," who finds the order of things rather narrow, and the "Scarabee," who is appalled by entomology as a whole and confines his investigation to the Coleoptera.

These characters are very suggestive to the civil engineer, who should combine a broad general knowledge of the order of things, with intensive specialization in some particular branch of his chosen profession.

This paper is not intended to decry mathematics, the fundamental basis of engineering, but merely to point out some of the necessary limitations of mathematics as applied to engineering construction.

The branch of pure mathematics most objected to by the practical engineer is the infinitesimal calculus, and some really great engineers have never been able to thoroughly master this subtle instrument of investigation.

It has been said that mathematicians are born and not made.

Probably this is true of such masters as Newton, Descartes and Leibnitz; but it should not deter any engineer from seeking such a knowledge of applied mathematics as will be useful to him in his work.

The late Lord Kelvin, better known as Sir William Thompson, could write down at once the result of many mental transformations in a way that was quite discouraging to his students at Glasgow. The story is told of him that when absent in London, being knighted by the Queen, a member of his class, then enjoying a respite from his short-cut methods, and having the advantage of the more detailed explanations of the assistant professor, Mr. Day, wrote upon the board, "Work while the day lasteth for soon the Knight cometh when no man can work."

Much of the difficulty encountered by the engineer in the use of the higher mathematics is due to insufficient drill in the philosophical basis of the subject. It is especially necessary to get a clear conception of the nature of flowing quantities and their conventional symbolic representation. A thorough knowledge of algebra is also required.

Arithmetic deals with numbers and numbers are discrete quantities, or may be represented as points upon a line.

Now in dealing with certain concepts, such as space, time, and theoretical curves, we are dealing with continuities, which cannot be represented by concrete or discrete numbers. There are no finite steps.

The necessity of some method of representing flowing or continuous quantities so that they could be subjected to analysis, led to the almost simultaneous development of the calculus by Newton and Leibnitz. Newton very appropriately naming his method "fluxions"—Leibnitz's method having a more convenient symbolism was the system generally adopted, and now known as the infinitesimal calculus.

At the first glance the methods of the calculus seem lacking in accuracy because of the throwing away of secondary differentials, but when the nature of "limits" is fully understood it is recognized that the method is essentially accurate.

Some day we shall have the cinematograph film used for mathematical instruction displaying to the student the gradual approximation of the differentials to the perfect curve.

One great difficulty is that of accurate definition unavoidable

in all exact analysis. The idea must be grasped that the zero of the calculus is usually not absolute zero, but only less than any assignable quantity.

A large part of the work of the calculus consists in the summation of an infinite series within certain arbitrary finite limits. If this was its only application, engineers, after their student days, might well accept the results obtained by mathematical specialists, as we all do in fact for most of the formulas in use.

But in the design of arches by the elastic theory, in double systems, deflections, the calculus becomes necessary.

Our conceptions of time and space are all based upon a division of these continuous quantities into arbitrary finite steps, varying from the recurrence of cotton planting times, and waxing and waning moons, to the seconds of an astronomical clock.

The calculus has enabled us by the idea of an infinite number of infinitely small steps to write the equation of these continuous quantities. It is conceded that there is great difficulty in getting a thorough comprehension of this idea; but on the other hand we can get ourselves into quite a metaphysical maze if we attempt a philosophical explanation of discrete numbers of integers.

Modern mathematicians are endeavoring to upset our fundamental notions of space with their new geometries.

While the infinitesimal calculus is a wonderful instrument of research in the hands of the skilled mathematician, it is not such a magical solvent of all difficulties as is sometimes assumed. You must be able to write your equation. Irregular curves have to be solved empirically or by the use of mechanical integrars, or methods of integration, such as the well-known planimeter. The writer found ordinary squared paper very useful in integrating time speed curves for rapid transit work, by the simple device of counting the squares.

Another important idea to grasp is that you can get from your mathematical mill only the product of the material that you feed into the hopper.

Mathematics transform, but create nothing.

To solve mechanical questions mathematically, we must abstract certain qualities, and follow determinate lines.

The older books in statics used to show a diagram in which two arrow-pointed lines projected from the ends of a third line at right angles and upon opposite sides. This was supposed to represent

a couple. No explanation was given as to what prevented the whole system straightening out into a right line; the necessary shear resistance not being mentioned.

As a matter of fact, all of the various resisting forces within a body must act together. Tension, compression and shear resistance are all the result of the combined molecular resistance to deformation.

Then we have the expression statics of rigid bodies, rigidity being a relative property of matter progressing through the successive stages of a limpid liquid, a viscid liquid and a plastic solid to a relatively rigid solid such as steel. Steel itself being sufficiently plastic to be drawn into wire, rolled into sheets and pressed cold into many shapes.

All metals can be made to flow under sufficient pressure properly applied. Into this process known as the flow of metals, time enters as an important element. The desired results cannot be accomplished instantaneously. The process of extrusion has long been applied to the production of seamless lead pipes, and the process is now being applied to the forming of numerous shapes in several different metals, the metal also being improved by the operation.

The force required varies with the metal. Lead in the form of filings can be compressed into solid metal with a pressure of 13 tons per square inch, and with the use of 32 tons will flow like water and obey hydraulic laws. Copper required 33 tons.

Soft and medium steel are readily manipulated by hydraulic pressure, thus shaping large objects from the sheet metal. If the proper time elapses during the operation to allow the molecules to adjust themselves, no internal stress results.

The theory of elastic forces in solids has recently been fully developed mathematically, making, however, many assumptions not fully accepted by all engineers.

The complications of the resulting formula can be best illustrated by the statement that one formula for non-isotropic bodies contains 21 coefficients.

The engineer in active practice at the present rate of compensation can scarcely find time for such mathematical gymnastics.

Such investigations are better suited for those mathematicians who, not content with exploring ordinary tri-dimensional space, plunge into hyper-space of "n" dimensions, study curved spaces,

and pursue the devious ways of non-Euclidean geometry, and non-Archimedean mechanics.

Another difficulty in statics is in the use of dynamical nomenclature, such as moment of inertia, and radius of gyration—not too easy of comprehension dynamically, but far harder to grasp when used statically.

There is, strictly speaking, no such thing as the center of gravity of a surface; but by assuming a very small thickness forming a disc, the idea becomes clearer. The English terms, centroid and "second moment," are less equivocal in the meaning.

The real difficulty in grasping the idea of the moment of inertia as applied to statics is that it is a biquadratic quantity, and as such could only be represented geometrically in space of four dimensions.

The nearest approach to visualization is when it is a case of the moment of inertia of a body about an axis exterior to itself, when you can represent it by a sphere equal in volume to the cubical quantity involved and a line representing the additional factor.

The section modulus being a cubical quantity is more easily visualized.

Even so great a mathematician as Henri Poincaré says that in neither physics or mechanics should we expect that any letter or symbol can fully represent the qualities of matter.

With exterior forces alone there is little difficulty, because it is then a matter of logical system applied to ideal concepts. Fortunately our principal structural material is nearly isotropic, so that we can apply mathematical theories to built-up or rolled shapes under approximately theoretical conditions. Of this the "I" beam is the best example and is a really great invention.

Recently an important improvement has been made by increasing the radius of curvature of the fillet joining web and flange at a point where its combined shear and tensile or compressive stresses are a maximum.

Let us now take up the inner nature of steel. Steel to the layman is a hard dense material of practically unlimited strength. To the man of science it is first a crystalline aggregate, crystals of pearlite, martinite, hardenite, etc., held together by cementite, or a mixture of cementite with uncombined graphite.

These crystals, which are beautifully shown by polishing and etching, vary in size and shape, and furthermore are very susceptible to thermic changes, affecting materially the strength of the steel.

They are held together by their own innate cohesive force, of which we know very little; and fracture may occur by sliding on their cleavage planes, thus splitting into smaller crystals.

These lines of displacement can often be clearly seen on the etched surface, or the failure may occur in the cementing material, the crystals separating, and this is perhaps the more unusual procedure.

Going now a step further into the constitution of steel, we find that the crystals are composed of more or less complex molecules, which in turn are but solar systems of atoms, almost infinitesimal spheres separated from each other by relatively large distances, and moving at incomprehensible velocities. The division of matter is now carried still further and we must imagine the atom as made up very much smaller corpuscles, and these are possibly only vortex rings in the ether, like smoke rings in the air, which mathematically are said to be the equivalent of a solid. We will stop, however, with the molecule as being the physical unit. These molecules are interpenetrated by an imponderable substance of such apparently contradictory qualities as to be practically inconceivable—of almost infinite elasticity, of a density far greater than steel, it is at the same time so tenuous that it offers scarcely appreciable resistance to the motions of the heavenly bodies. Matter, however, is only a sieve with very wide meshes.

Matter is made up of atoms separated by relatively large distances, while the generally accepted idea of the other is that it is a continuum. This will enable us to get the idea of its density. Steel is porous; the density that we measure is only that of particles diffused through this ether. If we knew the density of an atom of any element we could by means of the combining numbers calculate that of an atom or molecule of steel.

The ether is the only really rigid body in the universe.

All of this may seem rather far-fetched as relating to practical engineering, but fundamentally all molar stresses in matter resolve themselves into molecular stresses, and these are probably stresses or strains in the universal luminiferous ether.

The simplest reaction of a beam on a column is only explanable rationally by the intermolecular forces.

The fatigue of metal due to constantly reversed stresses for a long period, has been the subject of investigation, and recently it has been discovered that metals are subject to disease, and even

to contagious disease—the most conspicuous example being tin, which, when attacked, is converted into gray tin, a diseased granular condition in which the metal falls to pieces.

Various metals are also subject to poisoning, and exhibit thus the characteristics of a low form of life.

Crystals always assume the same shape for the same substance and grow, and repair damages quite like living objects.

The action of a rod or bar undergoing tensile stress in a testing machine is an interesting operation—the gradual yielding, the diminishing of cross section and the springing back when the pull is released all indicate the molecular flow of the metal.

When the bar parts the molecules have formed closed systems; the surface becomes covered with a film of air and moisture and the parts cannot be made to again adhere without heat.

This matter of flow comes into play in structural engineering, in the use of long tie rods, subject to transverse bending, which do not have to be figured for bending, as the gradual flow of the metal adjusts the stresses to the sagged shape.

An interesting statical question is the distribution of stress in a beam of rectangular cross-section subject to transverse bending. It is well known that a test to failure would show a greater resistance to tension than that obtained by direct tensible test. This is accounted for by hypothesis that the lateral adherence to the fibers forces upon the fibers nearest to the neutral axis an amount of stress greater than the theoretical stress due to their relative position. At first this was thought to apply only when the beam was tested to destruction and was not of much practical value, but it is now thought to apply also within the elastic limit.

This leads to a curious paradox. A question recently given in a local civil service examination related to the relative strength of a horizontal square beam, placed on its diagonal axis, vertical and horizontal. The question was whether the cutting off of top and bottom angles for 1″ in an 8″ square beam would make the beam weaker or stronger or leave it unchanged as to strength.

It proves to be a fact, mathematically demonstrable, that the beam is increased in strength by the truncation of the edges, within certain limits, which can be ascertained by the calculus.

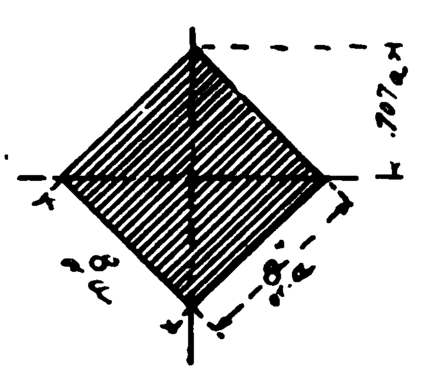
If the top and bottom edges the section, the section modulus increases until the vertical depth removed is equal to $.0787 \times a$. "A" being a side of the square, at this point it reaches a maximum and its modulus is $.1241A^3$.

If more than the above amount is cut off, the section modulus decreases, and when the depth, from the angle removed, is .1636a, the modulus becomes .1179A³. The moment of inertia of the truncated beam is, of course, less than the complete square beam. The gain on strength by truncation is due to a balancing between the effective cross section and the lever arm under which it acts. When the modulus figures for the two cross sections are drawn it is clearly shown.

The increase of strength due to the hardening of steel is believed to be due to the diminished size of the crystals, reducing the interspaces and giving more points of contact between the crystals

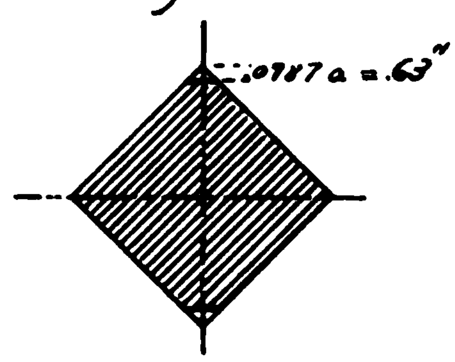
Tempering reduces internal stresses, but also to a large extent the gain in strength due to hardening is lost. Rolling and reworking disposes the crystals along the longitudinal axis, of course

Fig 1.



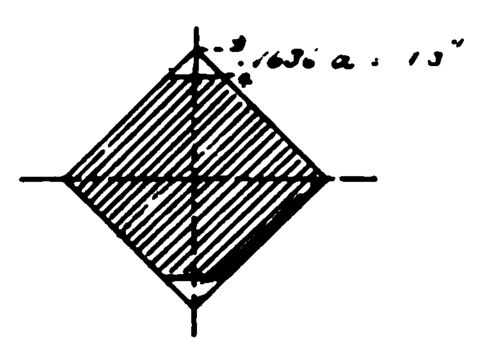
8" Square
Mod. .1179 a³

Fig. 2.



Max. Resistance
Mod. .1241 a³

Fig 3.



Equivalent of Square
Mod. .1179 a³

slightly increasing the distance apart of the molecules, but also bringing more crystals, and with the crystals more molecules, within the given cross section. Certain heat changes affect the compos - tion of the cementing material and this affects the strength.

The reaction of a support is a simple balancing of inter-molecular and intra-molecular forces against gravity.

Columns

It is only necessary to prepare a squared paper comparison diagram of the various column formulas, in good standing, to see how empirical is the present scientific knowledge of compressive resistance in members of any considerable length.

A little serious thought will also show the impossibility of a rational formula applicable to the whole range of the ratio of length to diameter.

The column will fail, according to its relative length, by flattening into a disc, by shearing at 45° or crumpling, or by cross-bending, which is the usual form of failures in columns used in structural engineering. When placed horizontally, the compression member as a strut has also to contend with the adverse influence of gravity. Fortunately, within reasonable, practicable limits, the variations are not too great to hope for a practical and rational solution; probably the straight line formula is as good as any.

The dangerous results of excentric loading have long been recognized as regards compression, but this is not as plainly evident in tensile loading.

Fig. 4.

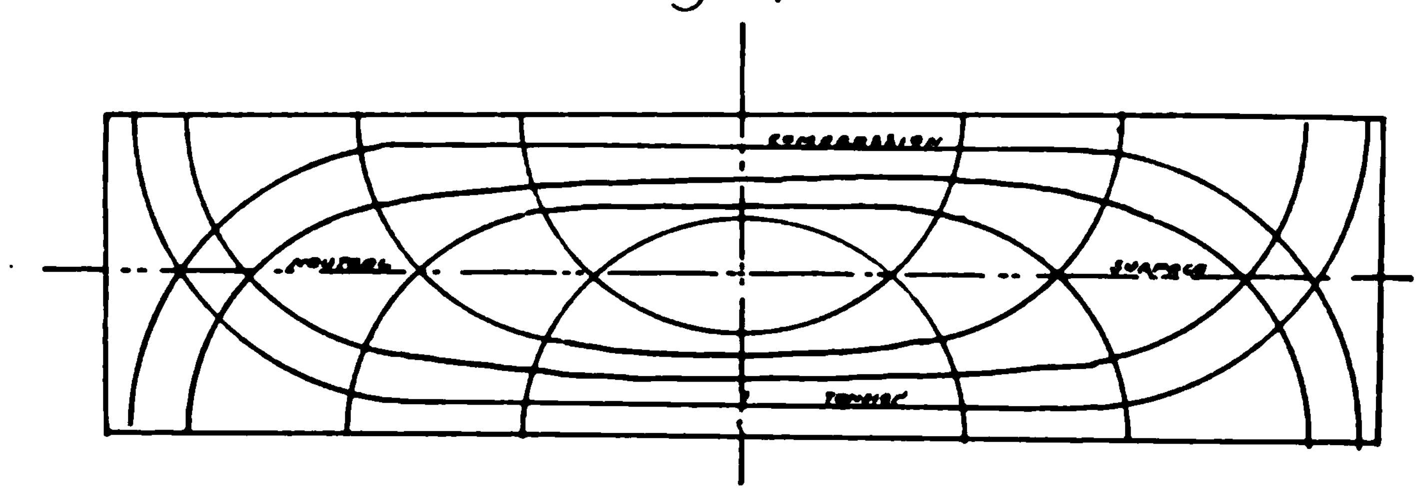
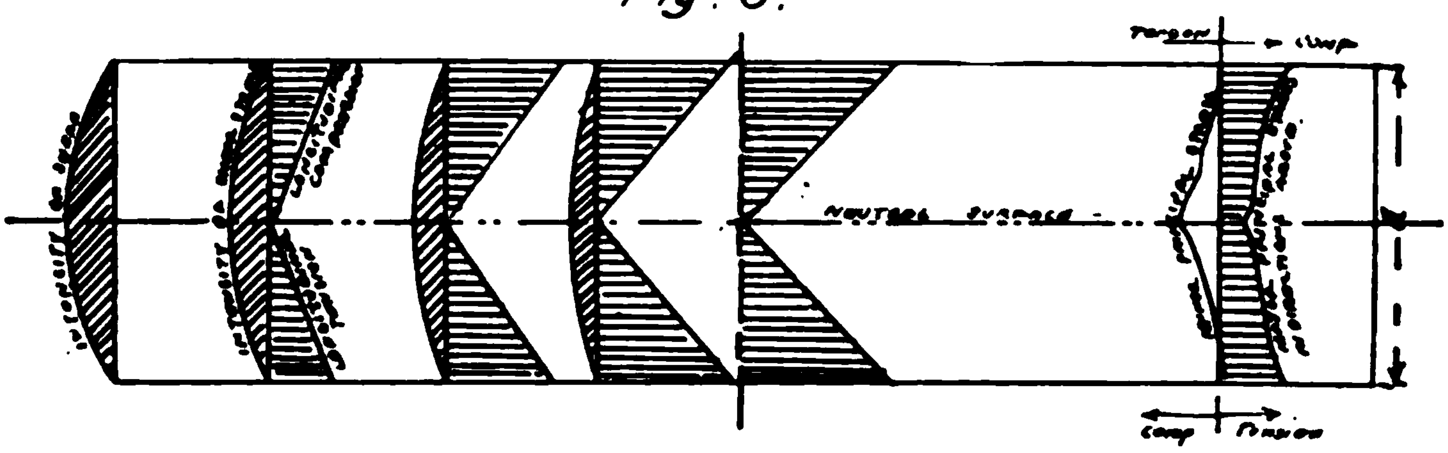


Fig. 5.



Any one familiar with the care required to get exactly axial pulls in a testing machine will readily understand the far greater difficulty in getting centric stresses in the practical use of ordinary unsymmetrical commercial sections. The result of these excentric pulls is a tearing action, quite different from true tensile stress, and may be illustrated in a homely manner; by the tearing off of a strip of muslin by a dry-goods clerk.

Framed Structures

In analyzing framed structures we encounter the difficulty that though we treat them as joined structures, they really have stiff joints.

It is sometimes stated that the hammer-beam truss exerts a horizontal thrust, but this is true only when it is improperly designed or constructed; if due allowance is made for bending in the main rafter, at the one point on each side where triangulation fails, it is as safe as any truss.

Tests have been made in England on a full-sized hammer-beam truss set up on supports placed slightly above the ground and then heavily loaded with bricks. It was found by careful measurements that the spreading was no greater than that permitted by the stretching of an ordinary horizontal tie-rod.

Domes

Domes when constructed in the orthodox way, with properly shaped voussoirs, theoretically at least, exerting only normal thrusts, permit of theoretical solution. In the steel dome the possible lines of action are limited to definite predetermined directions. But when we try to analyze the Gustavino dome, now successfully constructed with very large spans, we find our problem indeterminate. No theory of lines of pressure within the middle third can come into service.

Adhesion between the layers of overlapping tiles is evidently the saving feature, giving a very considerable tensile resistance.

Arches

Few arches approximate to the theoretical isolated arch, with its theoretical smooth voussoirs and no friction. Spandrel loadings, especially when these consist of bonded masonry, introduce conditions capable of taking up a large amount of horizontal thrust. The cement mortar of the joints also introduces an element of resistance that must be taken into account. The large arch laid up of hard brick in cement mortar is very far removed from the theoretical arch, and a graphical solution making use of imaginary large voussoirs does not give the true line of thrusts.

Retaining Walls.

The theories of retaining walls leave much to be desired and are in many cases but little better than empirical rules.

Baker says, in his masonry, under this head—"All theories assume that the coefficient of friction in the interior of the earth mass is the same as in the exterior slope; or, in other words, all

theories assume that the coefficient or internal friction is equal to the tangent of the angle of the natural surface slope."

The preceding examples illustrate that most, if not all, theories are logically self-contradictory, either in their fundamental assumptions or in their application to special cases.

1st assumption surface of rupture a plan

2d point of application of resultant ½ above base

3d relates to angle between the back of the wall and the resultant pressure.

Steel Base Slabs

Steel slab bases, now used as distributors of pressure between column and concrete footings, offer a more or less indeterminate problem.

Books on applied mechanics discuss the stresses in flat plates when uniformly loaded and either supported at the edges or secured at the edges, but the slab is a case in which the plate is supported at the center and uniformly loaded.

The problem is quite different from the steel grillage footing, because in that the lines of stress are predetermined by the position of the successive layers of the beams, which are stressed only in one direction.

The conditions are also quite different from those of the reinforced concrete footings, though the theories discussed for the latter offer some suggestions. The most satisfactory mode of calculation would seem to be to first calculate the unit stress of the uniformly distributed upward reaction of the concrete footings; then assume cantilevers of a unit width of say one inch and of the depth of the slab projecting from the four sides of the column base-plate; considering each cantilever as loaded with its own proportion of the unit load, plus its proportion of the amount carried by the corners, the corner load being supposed to be transmitted to the cantilevers on either side. There are, of course, other views of the matter. We may assume radial distribution with the difficulty that if our cantilevers are carried to the center, they have no width, and if stopped at the outer edge of column base, are narrowest at the point of greatest bending moment. As the tendency of the base plate or slab is undoubtedly to buckle rather than bend (that is, to bend in two directions), the question is how much allowance shall be made for this double or right angled resistance. The slab is in reality probably cubically stressed.

We will not take up the question of stresses and strains in mushroom system of reinforced concrete, as the subject is very intricate and is fully discussed in a recent issue of the proceedings of the American Society. The University of Illinois Testing Station has recently issued a report on the tests to failure of reinforced concrete footings. Other indeterminate problems of some moment are the proper size and placing of stiffeners on plate girders, and a good theory for latticing of columns. All formulas now in use assume incipient failure.

In many cases of doubt we can save the situation by adding some steel for good measure; but this is dangerous in gigantic structures in which the dead weight is more important than the live load. The weight increases as the cube of the dimensions, the strength only as the square.

The general tendency in engineering at the present day is towards simplification of structure. The abandonment as far as possible of continuous beams, the substitution of cantilevers in the place of continuous trusses, and the construction of but few double system trusses.

The idea that I have endeavored to bring out is that we should avoid the fallacy of analyzing mere definitions and postulates, assuming that the results correspond exactly with physical conditions in the material. To follow this up would draw us into the metaphysical discussion of nominalism and realism; but, avoiding that, we can easily see that no symbol or set of symbols can fully represent these physical conditions. The necessity of ample factors of safety is therefore evident; as is also the importance of checking by actual experimental tests of materials and structures. I will add a quotation from a recent number of "Engineering," London:

"Common-sense without mathematics will do a great deal, common-sense and mathematics will usually do more; but mathematics without common-sense, what need be said?" The writer speaks further of "illusively exact operations":

> "Alas the sprite that haunts us
>   Deceives our rash desire;
> It whispers of the glorious Gods
>   And leaves us in the mire.
> We cannot learn the cipher
>   That's writ upon our cell;
> Stars help us to the mystery
>   Which we could never spell.

"If but one hero knew it
The world could blush in flame;
The sage, till he knew the secret
Would hang his head for shame.
But our brothers have not read it;
Not one has found the key;
And henceforth all are comforted
We are but such as they."

Whenever a natural process is represented by mathematical symbols, it is well to remember that the artificial statement often expresses more than actually obtains in nature; because in the physical world only changes of a certain nature occur. We must, therefore, limit the generality of the mathematical expression.

MODERN INORGANIC CHEMISTRY,
J. W. MELLOR—1912.

"We draw the following conclusions; physics, in place of offering a more precise verification of classical mechanics, leads rather to correcting the principles, considered a priori as rigorous."

Les concepts Fondamentaux de la Science, Enriques, p. 267.
PARIS, 1913.

DISCUSSION

CHAIRMAN.—Mr. Button has given us an extremely interesting paper. I hope you will give it the discussion it deserves.

A MEMBER.—Mr. Button's diagram of shearing stresses in a beam indicated that the shearing stress varies from point in a vertical section of the beam; but the common theory of beams teaches that the shear is uniform throughout a vertical section.

MR. JOHN C. TRAUTWINE, JR.—The common theory of beams, in considering shearing stresses, regards the beam as divided into an indefinite number of vertical slices, free to slide vertically upon each other, but in deep beams it becomes necessary to take account of the fact that these shearing stresses are compounded with the longitudinal (tensile and compressive stresses) with the result that, at each point in the beam, the vertical unit shear and the horizontal unit shear are equal, and that the vertical shear (like the horizontal shear) varies from point to point in a vertical cross-section.

Mr. Button's diagram represents the directions of the maximum unit stresses (both normal and shearing stresses) at the different points in the beam, said directions being tangents to curves, as shown in the diagram.

A steel I-beam or plate girder acts much like a truss, the flanges (like the chords of the truss) taking the horizontal (tensile and compressive) stresses, while the web takes care of the shearing stresses; but, in our modern beams of reinforced concrete of rectangular section, these diagonal maximum stresses must not be ignored.

Mr. Quimby.—Taking these things in inverse order, the matter of truncating the square and weakening it is a fallacy. It is a fact that the section modulus is not as strong as if it had a full section, but that is only because with the full section you get a higher fiber stress, because the extreme fibers are square direct axis; with these truncated portions on you have more fibers to resist. It is a fact that the square is weaker in the diagonal direction that it is in the horizontal direction. If you have a long rod—no matter how you start the bending, if you do not heat it, when it does turn it will bend in the wrong direction. The stress is higher, and you have more fibers to resist the forces.

The trouble with the combination of mathematics and materials is not with the mathematics; it is with the quality of the material, which you never know exactly, and secondly with the effort to make the material resist different kinds of stress at the same time, and then you are uncertain in your combination. You can relieve that condition by testing your beam.

Say you start with a heavy member—a rectangular beam—and you get combinations of stresses which bring in uncertainties. You put in vertical members to take your shear—four diagonal ones if you choose, to take your tension stresses, and you put in horizontal members at the top to take compression, and the bottom to take tension, and you entirely relieve them of the uncertain conditions of stress. The trouble is not with the mathematics—mathematics is an exact science. The trouble is with the application of them.

The matter of steel slab bases reminds me of an interesting observation I made quite recently. The Pennsylvania Railroad has been engaged in rebuilding the highway bridge over Girard Avenue. On a recent Sunday afternoon I saw the bases of the tops of the piers that were under the columns, the columns having been removed. The plates were bent up between the ribs which bore upon them in service; they were permanently buckled up, perhaps as much as half an inch. The interesting part of it was that the top of the cap stone of the pier was shaped to correspond with it. It was Sunday afternoon, and I did not care to mess into the thing then, but when I went down there the next morning to see the columns, they were removed—taken away during the night—and the holes were filled up. I dug out one of the holes and examined the stone, which extended perhaps 8 or 10″ beyond the base plate of the column. There was a depression over the whole area of the base plate of the column base—the rib members are ⅜″ deep, and around the edges—well, the whole line of the base plate was shown in the stone. I found it was a stone much like that which comes from Glenn Mills; it was not hard enough to resist the continual pounding; it was pulverized, and the plate was not sufficiently stiff to distribute pressure enough to prevent that.

Mr. Trautwine.—That was not strictly compression, though.

Mr. Quimby.—Not the wearing away.

Mr. Button's statement that materials exhibit some indications of low forms of life is interesting to me, and I think it is true. I believe that inorganic substances have, to some extent, the characteristics of organic life. I believe, that material, steel, say, is strengthened by exercise just as our muscles are. I believe that it is subject to diseases just as we are, and probably of more than

load was figured at 200 pounds per square inch, and it collapsed. I figured that there was 2,000 pounds stress per square inch.

MR. CARL HERING.—This subject of mathematics applied to engineering recalls a case in which a number of engineers each worked out a different formula for the draw bar pull in traction; and they included in their formulas all sorts of things factors like head-on wind pressure, velocities, curves, grades, etc., hence included some refinements. Each claimed his was the most accurate. But a fireman of a locomotive once remarked that he didn't care about a head wind, but that when the wind came from the side it made him work much harder. There was a most important factor, therefore, namely a wind from the side, which had not been thought of or included by the constructors of these formulas.

Another instance, which occured at a meeting of this Club, is that of the straps around a wooden stave pipe. These straps are put on under great tension. The water pressure in the pipe then puts an additional tension on the straps, and the question is whether this additional tension has to be borne by the straps. The speaker of the evening said that it did. As a matter of fact, that is not correct. Up to a certain limit the straps will not be stretched any more after the pressure is in the pipe than they were when they were put on. That discussion was published in our proceedings, and anybody interested can find it there. It shows how easily we can be misled by applying mathematical formulas, without careful judgment.

placed to them from time to time, without taking thought as to how such plans are related to each other or to the whole, or how they act upon the people who inhabit the physical city, whether the amounts apportioned for them are, as compared with city needs, apportioned equitably, or whether they are apportioned without vision and, hence, are unbalanced; whether they tend to develop the best living and working and pleasure conditions for the people, or whether they are designed to yield a profitable return for special interests whose invested capital and profits might be jeopardized or enhanced; and lastly, whether they are projected in the light of modern scientific knowledge, demonstrating the effect of environmental influences upon public health, morals and comfort.

In all this, the central figure is man. It is he that is the object of consideration, and for his welfare are all things justified. A peopleless city is valueless. The cliff homes of New Mexico cannot stir up an appropriation from Councils (though perhaps they might get into an appropriation bill in the State Legislature). No one thinks of improvements in connection with them because there are no human things living there to give an excuse for the projection of the improvements. In Philadelphia matters are different. If an appropriation is asked for water mains it is because such are proposed for utilitarian purposes; if sewer pipes, that they may be of service. If streets are laid out and built they are for use. If parkways and boulevards are projected, the only justifiable excuse is that they may facilitate traffic or become objects of beauty and pleasure for the community. The same is the case whether it is a new public library, art museum, convention hall, high school or what not. The justification behind them all is that they minister to some public use, answer some public need.

In the consideration, therefore, of municipal improvements the important question is, in how far do they benefit man and in how far do they interfere with his best interest? If they are for him, then there is only one consideration of prime importance: namely, do they help him or do they hurt him, either by withholding from him other and more important improvements or by fastening upon him problems he did not previously have, and which in themselves seriously handicap him? This is not a radical requirement though it is fundamental, and in reality furnishes us with a measuring rod whereby we can tell the real value of municipal projects past and future.

health and public morals were thereby intensified; to what extent I will point out later.

We, of this city, are fond of contrasting ourselves and our conditions of living with other cities, and always to our own favor. We breathe many a sigh of relief that we are not as New York is. Fortunately, indeed, for us we have not New York's tall tenements. *Nevertheless, we have congestion of population and building congestion that destroys privacy* and assaults our poor in as many vicious ways as do the tenements of New York. Remember the width of our streets in the older parts of the city, then remember what I have said about the subdivision of the blocks, the lack of yards, the alleys and courts. The waste here, due to bad municipal engineering, is economic as well and civic. "The river of national health must rise from the homes of the people and from each individual home," says Dr. Richardson, the English specialist. If the home is lacking in the fundamental essentials for health, that is, proper ventilation, sanitation, living and playing space, if it is overcrowded, if the light is poor so that the occupants are living in gloom all the day, if there are dozens of other homes of like character nearby, what chance has any one of them to become a source of purity or strength? It is absurdity reduced to its most absurd limits.

But there is another side of this. Such subdivision of the land so as to build back lot houses *has been legally stopped. The laying out of streets on a narrow basis without any precautions* to control the use of such streets or the permanency of the type of occupancy is still going on. The minimum requirements for the open areas in and about buildings has been changed so that instead of permitting a family to share an alley with the adjoining families for a playground, the law now says each house shall have at least 144 square feet of open space, but the builder can put it in a strip running along the side and back of the house in any width he wishes Some have made this strip five feet wide. The neighboring owner has built clean up to his property line, thus producing as vicious a type of an alley as anything perpetrated in the olden days. It is entirely feasible to house a population, under our present building code, of 300 people, in small dwellings, to the acre, including streets in the estimate. If recourse is made to the tenement type, building only four-story houses, we can easily create a density of 1,000 people to the acre. *These evils are visionary, do you say?*

gang is called in more frequently. You may say these are small items, but in every budget it is the small item that ordinarily escapes and that makes the bills soar. The point I am making here is this. With the failure of the city to lay out its streets on a scientific basis and with the attendant failure to regulate the changes in the character of the occupancy of the neighborhood, these evils creep in; and the cost to the city attendant upon the transition fastens a burden upon the people in added taxes, in economic prices, in health, morals and personal fitness.

It would seem, therefore, that the lay-out of the city streets, affecting as it does the economic use of the city blocks, would *be a proper field for scientific municipal engineering*, and that the mistaken plans now fixed by ordinance over large and undeveloped areas within the city might be subject to special study and revision; while, at the same time, the area requirements for open space about buildings should be changed so as to protect the future against the duplication of the mistakes of the past.

Then, again, and let me cite these rather rapidly, there is the need for an underdrainage program for the city. To meet the needs of a city growing about 25,000 people a year there must be a definite plan so as to anticipate developments and to prepare the streets below the surface before the street above the surface has been completed. How inadequately this has been done is illustrated by the simple statement that there are approximately 42 miles of streets in the older parts of the city that are without sewers. When you remember that nearly all of these are wholly or partially built up and that the failure to lay pipes is responsible for two of the most pernicious of nuisances, surface drainage and the privy vault, you will appreciate the waste in human life, health, and well-being thus caused. For be it remembered that, as Mr. Vogleson, of the Health Board, says, "The death rate of the city is directly related to its sanitary condition." E. F. Smith, in an early book on the subject, calls attention to the fact that when a city has been underdrained the death rate has dropped and never again climbs to the former heights. If this is the effect of underdrainage on a city as a whole, it must likewise be the effect upon the city in all its parts. Where the lack of proper drainage exists, the city is to that extent exposing the people there to disease risks. The skeptic can easily assure himself of the truth of this if he will go into the obnoxious conditions produced by the privy vault which

of all sorts and conditions. It has removed some that were exceedingly bad and others that were good. At a modest estimate it has taken the homes of from 1,500 to 2,000 people. For those of comfortable circumstances the removal did no harm for they could find plenty of houses as good as the ones they had occupied for rent or purchase. But the poor were sent into the congested sections to intensify the congestion. They had to go where they could get rooms for the rent within their means. Thus the city took the homes of the poor to make a fine boulevard, but it did not consider the added problem it forced upon these poor and others in similar circumstances. What I am seeking to emphasize here is that a satisfactory city program will never contemplate improvements without counting the cost and making provisions for those whom the improvements displace. The renting of houses is subject to the law of supply and demand and the demolition of any arge number of homes without the erection of others to replace them throws the balance over against the man who pays the rent. This means eventually increased rents, smaller apartments for the very poor and all the evils that attend overcrowding.

In like manner all improvements of whatever nature have their effect for good or for evil upon home life. The location and size of factories, store houses, terminals, wharves and docks, steam railroads, transit lines, tunnels and elevated, centers of commercial life, all affect the environment of man and determine for him to a large extent the health opportunities of his home.

This survey has necessarily been hasty. I do not pretend it is more than an index of causes that rightly co-ordinated develop a community by being considered as separate units without relation to each other and to the dwellings of men produce the evils we find so plentiful in all our large cities and all too plentiful in the city of Philadelphia.

You ask what is the cost of bad housing to the people of Philadelphia? I very much fear I would have some difficulty in answering that question off-hand, for it would require an amount of special research that my time just now would not justify. You see we would have to approach an answer from the health side, the economic side, and the moral side. So far as I have been able to ascertain no one has gone into any of these aspects of housing of Philadelphia so as to be able to give an answer at all approximating accuracy. It has been worked out to a limited extent, just enough

cause and effect so that even the greenest novice of a juror or magistrate can see it, the excuse for noxious conditions to remain is removed. Other cities have made such studies and it is upon their work we have to depend for the scientific statement of the consequences in ill health from bad housing.

Data has been tabulated of the general effect of city life upon public health both in England and in Germany. Horsfall, in England, states that only 1,000 Manchester men out of 11,000 examined were physically fit for the army at the time of the Boer War.

Prof. Pasadowsky, in Germany, reports a study of 621,210 German soldiers and sailors. Notwithstanding the enforced service of all young men in the Empire physically fit for duty, yet two-thirds of the enrollment of both divisions came from the country districts. This difference becomes even more strikingly pronounced when it is remembered that there are 5,000,000 more in the cities than in the country districts.

Measured by army standards of physical well-being, the effect of congested community living, under adverse circumstances, is wearing on men. But let us bring this record down to the areas in which the large proportion of bad housing conditions are to be found, and see what we find. Overcrowding or congestion is a large factor in increasing deaths. For example, Dr. Newman, Medical Health Officer for Finsbury, reported the ratio of deaths to 1,000 population in four-room houses, in his district, to be 6.04, while the ratio of deaths for one-room houses was 39. That is, under the more sub-normal, congested living, over six times more persons died each year than in the more normal conditions. In Glasgow, a few years earlier, figures not quite so startling were unearthed. The one-room homes had a death rate of 32.7 per 1,000 while the four-room homes had only 11.2.

Then again, take the records of the houses as regards block ventilation. A study of 13 cities in West Yorkshire, England, showed an average death rate in houses open on two sides to air currents of 15.51 per thousand, while those houses built back-to-back had a death rate of 17.94 per thousand persons. The record for pulmonary diseases, excluding phthisis, was equally enlightening. Here the comparison was 3.6 in the well ventilated houses and 4.44 in the poorly ventilated houses.

These figures are especially interesting in that in this city we

have many back-to-back alley houses improperly ventilated and lighted. The contrast for the same disease in the crowded houses in London is likewise extreme. Thus one-room houses have a rate of 3.4 as contrasted with 1.4 in three-room houses. While for other respiratory diseases the rate for the one-room is 8.3 as compared with 2.9 for three-rooms.

Perhaps as good an illustration of the handicap bad housing puts upon the public is presented in the figures of development of the school children in Glasgow. In this study the school authorities took records of 78,857 children between the ages of 5 and 18 years. Boys living in one-room houses weighed 52.6 pounds and were 46.6 inches high, while those in four or more rooms weighed 64.3 pounds and were 51.3 inches high. The effect upon the girls was even more striking. Those living in one room weighed 51.5 pounds and were 46.3 inches high as contrasted with those in four or more rooms who weighed 65.5 pounds and stood 51.6 inches high. The school authorities, commenting on these figures, say the difference in so many homes cannot be due to accident and put the blame squarely upon the environmental influences that are so bad.

Now it may be claimed that there is a multitude of other causes producing these defects, and housing is not so great a factor as it would at first seem. It is not the only factor. In other words, the chances for a baby to live were more than twice as good amid the good housing conditions as amid the bad. Even more effective a presentation of the differences is found in the Liverpool figures. In one large area where the old back-to-back houses and rookeries were torn away and, in their place, 2,663 new houses were built with opportunities for light and air afforded for each room, the death rate declined from 60 to 27 per thousand; tuberculosis from 4 to 1.9 per thousand; typhoid fever, from 1,300 cases in 1896 to 200 cases in 1911. The change was not due to a new population moving in, for over 70% of the old population were rehoused. In Glasgow, where a similar rehousing took place, the death rate declined in the new housed areas from 43.7 to 26 per thousand. Similar testimony from many sources can be cited and can be sifted to trace the responsibility to bad housing.

The point of it all is simply this: Are we, as citizens, intelligent enough to work for public health along scientific lines? Or are we so short-sighted in our health policy that we are content to

go on caring for and curing the victims while we neglect the causes that produce them? Justice Hughes once said it was foolhardy to keep on increasing appropriations to care for the victims of bad housing while we overlooked the conditions that produced them.

What we need in Philadelphia is a constructive program that will eliminate present evils and prevent the development of new areas along the lines of past mistakes. Patchwork programs and temporizing policies should be relegated to the incinerating plant.

It might be difficult just now to demonstrate to Philadelphians there is any connection between bad housing conditions and sickness and a high death rate. It is commonly known to sanitarians that the sanitation of Philadelphia, in certain wards, is especially bad. Until the past year the death rate for the city was very high. In 1912 it dropped to 15.22 per 1,000, and in the minds of some people this was proof positive of the falsity of the statements about the insanitation prevalent. As a rule, the death rate for a single year is a mighty poor barometer of the actual health conditions, so many factors enter in to make the mercury go up or down. We did have a low death rate last year, but so did other cities in the country. Out of 36 other cities of over 100,000 population 23 also reduced their rate, some as high a reduction as 2.1 and 2.4 and 2.63 per thousand. Exceptional conditions favored the public and reduced for the time the toll levied on them by the insanitary areas. Even then, as a matter of fact, out of 45 registration cities having populations of over 100,000, reports from which have come to our office, 23 had lower death rates than Philadelphia and 21 higher rates. Among the cities having a lower death rate were Chicago and New York, although both have a larger population. Although, therefore, we dropped lower last year than ever before in our rate, yet we need not become too self-satisfied. We are still 24th from the top on the list of large cities, and approximately during the year 8,000 deaths occurred from diseases that are scientifically known as preventable. If these preventable deaths were from any cataclysmic cause we would be horrified. "If such a calamity occurred in a single day and it was preventable," to quote a well-known insurance society, "and was not prevented, the dereliction would be regarded as a crime." "Is it any less a crime," they add, "that it takes 365 days instead of one day to destroy these lives?" Not all, by any means, of these deaths can be laid at the door of bad housing, but without doubt a large percentage

forms. Society loses in the bills it has to pay for the care and prevention of the spread of contagion and the victims of such. Do you realize that in five years from 1907 to 1911 there were 109,066 cases of contagious diseases from six of the 27 diseases classified by the Board of Health as contagious. Of this number, 31,375 deaths occurred. I have not had time to determine the number of cases of such diseases cared for by the city and private hospitals as charity cases, but I know that the average cost for a number of years to the city for hospital care is $2.00 per day per patient. There is added to this the annual cost paid for the work of the Health Bureau. For the child sent to the reformatories, etc., there is a weekly cost of $3.00 per child. When you realize that we are 20 centuries almost away from the date Christianity is supposed to have begun and the far longer period civilization has been at work upon the race, it is a sad commentary upon the work done that we need larger hospitals and asylums and poor-houses, larger police force, larger and more courts, judges and all the kindred staff called into being by the manner of living of men. Not all, by any means, is traceable to bad housing but this plays a large part, in that environmental influences are at play to mould for good or ill those who come within its sphere. If the figures of English statisticians are correct there is an average of 20 cases of sickness for each death and 20 days' loss of work for each sickness. On this basis the economic loss to Philadelphia for the 8,000 to 9,000 lives needlessly sacrificed amounts to from four to six millions, a loss that is increased when it is remembered that with it goes the drain upon public and private charities for the care and upkeep of the families thrown by such sickness over the cliffs into the chasm of poverty.

I do not intend to appear a calamity howler in this matter, but the conditions are here and in every city. They are the consequences of a lack of a community program. Such a community program is readily drafted. It needs the attention of men of your profession. I can best let my last remark to you be a repetition of a question asked of me by a poor man in a southern ward: "What are you going to do about it?"

Mr. Trautwine.—I entirely agree with Mr. Hess, and I regret that I expressed myself so unskillfully as to cause him to misunderstand me. I have the greatest faith in the human individual—if he is given half a chance, and I heartily second Mr. Newman's plea that he be given a chance.

And I gladly accept the amendment, substituting "ascending spiral" for "vicious circle"; but pictures such as Mr. Newman has shown us lead us to wish that the spiral might ascend a little more rapidly.

shafts with concrete. This required that the plant left by the contractor be overhauled and added to. Timber headframes were substituted for the derricks over the shafts, new hoisting engines of a heavier type were installed, and a new compressor plant was established for the west side, the plant used by the contractor for both sides being concentrated for use at the East shaft.

When these preparations were completed it was necessary to unwater the shafts, which were practically full. This was done by bailing supplemented by pumping. It was not until March 3, 1909, that the excavation work was again started in the East shaft, and on June 2 of the same year in the West shaft, the first work being the excavation of the diamond drill chambers, before noted. Before the diamond drilling was started the shafts were sunk an additional depth of 50 feet or more so as not to interfere with the drilling. As the shafts were sunk pump chambers were excavated in the sides approximately at elevations —400 and —800, the idea being to pump from the contingent 1200-foot level in 3 lifts. The chambers were made large enough for the installation of 3 Jeanesville, two-cylinder, 16x7x18, plunger pumps, rated for 400 gallons per minute against a 500-ft. head. The amount of water to be handled was, of course, problematical, but the above installation was intended to be good for at least 800 G. P. M. with one pump in reserve.

It is only necessary to mention a few of the features of the shaft sinking. The timbering consisted of 8x8 yellow pine sets, placed 5½ feet on centers, and lagged with 2-inch plank. A clear way of 9 feet 8 inches x 9 feet 10 inches was left. The timbering was done in sections of 50 feet to 100 feet, depending on the character of the rock, excavating being suspended while the timbering was in progress. The first step in timbering was to place in niches cut in the rock four 10x12 oak bearing timbers, from which the sets were built up until the gap was closed at the next set of bearing timbers above. For about 5 feet above the bearing timbers the space behind the lagging was filled with cord wood. At wet places in the shafts a concrete ring with a small sump was built at the top of the packing, and a small pump installed, which lifted the water up to the station pumps in the chamber above. When the next chamber below was ready the pump in the ring was removed and the water piped down to the chamber.

The leakage into the shafts was remarkably small considering

their proximity to the river. Only 30 G. P. M. was pumped from the 1153 feet of the West shaft. In the East shaft an inflow of about 120 G. P. M. was encountered in the vicinity of elevation —400, most of it in the pump chamber. This delayed progress materially until the water was confined to the sump in the chamber. The difficulty was increased by the fact that at the same time the first inclined boring from this shaft was adding about 180 gallons to the amount to be pumped when the hole was open; that is while the rods were withdrawn. At times, 350 gallons per minute were being pumped to the surface. The closing of the drill hole when finished reduced the inflow so that when the bottom of the shaft was reached about 140 G. P. M. were being handled, or less than the maximum amount delivered through the small drill hole. Ventilation was provided in the East shaft through a sheathed "smokejack" into which a pump exhaust was led. In the West shaft a similar function was performed by an exhaust fan and spiral pipe.

Generally the rock encountered in the shafts (classified by geologists as granitic gneiss with diorite veins) was firm and hard, but at elevation —450 in the West shaft a peculiar behavior was first noted. At this elevation "popping" rock was first encountered. Apparently the rock was under severe pressure, the local relief given by the shaft excavation causing small slabs to fly from the sides of the excavation with a popping noise. This behavior of the rock was naturally disconcerting to the workmen. The trouble from the popping rock increased to such an extent as the shafts deepened that it became necessary, in order to protect the men and to maintain progress, to keep the shaft support closer to the bottom than was practicable with timbers. The blasting would knock out the timbers unless they were at least 25 feet up. Furthermore, the time necessary to cut niches for bearing timbers was a large proportion of the period required for timbering a 50 to 100 foot stretch of shaft. A form of steel support, easy of erection, was therefore designed, consisting of 8-inch channel ribs spaced 4 ft. 1 inch on centers, and lagged with ⅜-inch plates curved to the radius of the rings. The plates were bolted to the outside of the channels which were bent with flanges in. The ribs were formed of 4 quadrants bolted together with fish plates and were placed by hanging from the next higher ring by long bolts with pipe separators. Every third or fourth ring was further sup-

ported by resting it on steel dowels driven into holes in the rock. It was practicable to keep this steel support within 15 to 25 feet of the shaft bottom. The conditions were so bad at times, however, in spite of all the precautions taken, that a number of miners were injured, one fatally, by the falling rock. A peculiarity of the popping was that it seemed to affect most the hardest and best rock in the workings; that is, the rock that would generally be considered best for tunneling operations.

The maximum monthly shaft sinking progress in the East shaft was 65 feet, and in the West, 69 feet, both made when the shafts were nearly their full depth. The fixing of the tunnel elevation, late in 1910, acted as a great impetus to the shaft sinking. Everyone connected with the work appeared anxious to get started on the under-river tunnel, the completion of which would set at rest all uncertainties regarding the Hudson Crossing.

River Tunnel

The first round of holes for turning the river heading was drilled in the East shaft on December 23, 1910, and in the West shaft on February 13, 1911. The headings were then driven 100 feet or so from the shaft. A pump chamber was excavated at the bottom of the West shaft, and the East shaft was sunk 40 feet or more deeper to form the large permanent sump for this pump shaft.

One cage was installed in each shaft, the timbering not permitting two cages. The cage in the East shaft was 6 feet 2 inches x 8 feet, and in the West shaft, 5 feet x 7 feet 2 inches. When these cages were installed, preparations were made to drive the heading under the river.

It was then considered that the exploration work was finished, and that the remaining work should be completed by contract. A contract, No. 90, was accordingly prepared, to include particularly the following features:

1. The completion of the tunnel excavation under the river.
2. The lining of the tunnel with concrete to a finished diameter of 14 feet.
3. The lining of the West shaft to the same diameter up to the land tunnel connection, and the sealing and partial refilling of the shaft above it.
4. The lining of the East shaft to a finished diameter of 14 feet

order to avoid pumping the water from the bottom during these preparations a 4-inch pipe was inserted in the cut, carefully braced in position and bedded in concrete, and then extended back to the shaft and 300 feet up the latter to the pump chamber at elevation —800. A valve in the pipe was kept open so that there was no head against the concrete while it was setting. When the concrete had set the valve was closed and the water rose under its own head to the chamber, 300 feet above. This pipe was kept in service for several months until preparations for advancing the heading were completed.

As a matter of additional precaution a concrete bulkhead was built in the tunnel by the contractor as close to the heading as was practicable. This bulkhead was 14 feet thick in the middle, increasing to 18 feet at its contact with the rock. Through it was an opening large enough to pass the muck cars, and closed by a cast-steel door, 3 inches thick, opening against the possible flow of water. It was so arranged that it could be closed quickly if necessity demanded. The pipes for air mains, pump discharge, electrical connections, etc., were built into the bulkhead.

While the bulkhead was being built and the new pumps installed, the contractor took advantage of the delay to have a diamond drill hole bored into the face of the heading parallel with the axis of the tunnel to explore the ground ahead for waterbearing seams. Although this hole was driven a distance of about 500 feet, a flow of only 32 G. P. M. was encountered, about half of it coming from within 10 feet of the face of the heading. Additional air drill holes were put into the face of the heading from 10 to 12 feet deep. Some of them encountered water and others in very close proximity did not. For example, a hole drilled 12 feet deep at an angle of 45° with the tunnel axis yielded no water, while another started close by the collar of the first yielded about 400 G. P. M. at one-half the depth. In each hole a pipe was driven for use in grouting, and provided with a valve at its outer end. When all this had been done a concrete bulkhead, 4 or 5 feet thick, heavily reinforced with pieces of steel doweled into the rock, was built against the face of the heading, allowing the grout pipes to project through. After the concrete was set an attempt was made to cut off the flow of water by grouting. This grouting was accomplished by means of a Cameron pump with large air and small water end so arranged as to pump water through a Cannif grout

	Tunnel Water	*River Water*
Total solids	6721	615
Sulphuric anhydride	303	41
Lime	971	35
Magnesia	183	36
Chlorine	3210	258

All in parts per million.

The difference in calcium and total solids is notable. The chlorine content of river water varies greatly with the tide and amount of fresh water flow. The analysis of tunnel water did not change materially in the three years it was under observation. The theory has been advanced that the tunnel water comes from the river, its altered chemical composition resulting from passing through a stratum of gypsum-bearing rock.

Only one other waterbearing seam was encountered in the east heading, and the inflow of about 100 G. P. M. was easily handled by the pumps.

The electrically driven centrifugal pumps, namely 2 Worthington, 8 stage pumps with 10-inch discharge to the top of shaft, were operated intermittently to remove the water. Current for these pumps was generated by a Curtis steam turbine generator near the shaft top, a cable laid in the bed of the river supplying current to the West shaft, transformers giving the desired voltage of 450. Although 2 electrically driven centrifugal pumps were installed at foot of the west shaft as a precautionary measure, they were not used, there hardly being enough water to properly test them.

The 2,090 ft. tunnel driven from the west shaft was almost perfectly dry, the total inflow amounting to less than 10 G. P. M. A pilot hole was drilled in the west heading about 5 feet in advance of the expected heading round to give information of possible waterbearing seams. A similar precaution was taken in the east heading after the excavation reached the end of the horizontal diamond drill hole above referred to. These pilot holes were drilled with the ordinary air drill.

The driving of the remainder of the tunnel was continued until the headings met on January 30, 1912, 915 feet from the east, and 2,090 feet from the west shaft. The meeting was celebrated wit' ia' monies, the Mayor of the city attending and fir error in alignment at the point of meeting

ft. sump, the placing of two pairs of concrete guides from bottom to top, and special metal construction at the top to withstand heavy bursting and lifting pressures. The west shaft was to be lined as an ordinary waterway shaft, and presented no unusual difficulties. Accordingly, it was planned by the contractor to line practically the entire tunnel excepting the invert from the west shaft. The invert, about 5 feet in width, was placed for the entire tunnel, three 45-ft. sets of Blaw tunnel forms being set up on the completed invert, dividing the tunnel into thirds. The so-called "trailing" form method was used in concreting. A length or two of sidewall (invert to spring line) was first poured at each set of forms, thereby permitting the erection of the arch form. The subsequent day's work required the arch form to be filled to the key, and during the keying operation, which could use only a few men, the next sidewall form was concreted. The use of three sets of forms permitted one to be filled each day and another moved. Those interested in complete descriptions of tunnel lining methods, which have been highly developed on the Catskill work, are referred to Mr. White's book, and to the bibliography in the Appendix thereof. The following description of the concreting plant used at the Hudson river crossing, and the method of concreting is quoted from Mr. White's book.

"A very convenient plant was installed at the top of the west shaft to supply concrete for the entire tunnel. Barges of sand and broken stone were unloaded at the dock by a derrick and grab bucket which filled a small hopper feeding on to a belt which in turn discharged into a longitudinal belt over the sand and stone bins near the shaft. The belt over the bin was equipped with a tripper so that the bins could be kept uniformly filled. The concrete measuring and charging cars were filled from the bins and hauled by a small hoist up an incline to a large Smith mixer, which discharged a batch twice the usual size directly into a large twin-hopper car on the cage. This car at the bottom of the shaft automatically discharged into two cars, one each side of the shaft. The concrete cars were hauled by electric trolley dinkies to the forms, which were used in a manner very similar to that employed at the Wallkill and Rondout siphons. Although a 40-foot side wall and arch form was filled daily, it is reported that the single cage is a considerable handicap during concreting, as there was little time to take the hopper car off and use the cage for other purposes such as cleaning and mucking out tunnel, etc. A particularly rich mix, about 1–1½–3 (2 barrels

cement per yard) was used for all the concrete in order to secure water-tightness. The lining averaged at least 17 inches effective thickness."

Grouting of Tunnel

During the progress of lining, pipes for grouting were set at seams in the rock, high points in the roof and near the ends of sections of roof concrete, in order to cut off water, fill voids over the concrete arch and close openings in the arch at ends of successive days' work. The grouting was done in two operations. After the completion of the entire lining, the first, or low pressure work, was placed by air up to 100 pounds pressure, the second, the high pressure work placed by air up to 300 pounds, and by pump from 300 to 600 pounds. Neat cement grout was used in some cases, and in others equal parts of cement and sand. The grouting was generally successful except toward the east end of the tunnel where trouble was experienced with cracking the concrete lining by the application of the high grouting pressures. Through this stretch trouble was experienced during the concreting because of the seepage of water through the rock, and the quality of the concrete was apparently affected thereby. A few pipes were left ungrouted and equipped with bronze check valves to close against the internal pressure, thereby preventing loss of water outward, and to open with the external pressure, thereby relieving the tremendous pressure on the concrete lining when the tunnel is unwatered for inspection. Special tanks were built to withstand the high pressures used in the water pumping method.

Shaft Lining

The lining of the west shaft presented no difficulties, as the shaft was practically dry. Steel or timber support was removed in convenient stretches and the concrete placed behind Blaw steel forms in sections up to 20 feet in length. The removal of shaft timber necessitated the use of bucket transportation, concrete being dumped on to a platform on top of the forms and then shoveled into the forms. Pump chambers were filled with concrete as reached, and later grouted. After the final cleaning of the tunnel and removal of plant from same, the 50-ft. plug over the junction with land tunnel was concreted, this operation practically completing the west shaft.

The lining of the east shaft was a more difficult operation because of the greater amount of water and the complications resulting from the concrete guides which were built monolithic with the lining. These guides (two pairs) serve to guide the cage, float and discharge pipe in the unwatering operation, and hence must be very true as to alignment, clearances, etc. Special forms were required, the guide forms themselves being castings attached to the circular steel form. A 5-inch galvanized pipe was built into the lining in a vertical position for possible use as a discharge line in future maintenance operations. The general methods of concreting were similar to those used in the west shaft, but progress was necessarily slower because of the guides. Some grouting of the shaft lining was required where the rock was seamy and water-bearing.

Special Construction at Top of East Shaft

As stated before this shaft will be used as a pump shaft for unwatering the Moodna-Hudson tunnel. Comparatively easy access must, therefore, be provided, and at the same time the construction for withstanding the enormous bursting pressures when the aqueduct is in service must be adequate and watertight. Fig. 5 shows the special construction in detail.

The total pressure under the cover during service will be about 1,975 tons, or 12½ tons per square foot. To aid in securing watertightness an interlining of riveted steel, ⅜″ thick, 14′ 10″ diameter, is provided in the concrete lining, starting at elevation —175 and continuing up the shaft to about elevation +10, where it is attached to the cast-steel curb on which the heavy steel cover rests. This interlining was provided with inside flanges at circular joints and was lowered into the shaft in full sections, generally about 15 ft. long, the circular joints being bolt connected and calked. Previous to placing any of the permanent work above elevation —175, all timber was removed between that level and the top of the shaft. The concrete lining was carried up outside and inside the interlining as the latter was built up. At about elevation —36 comes the so-called anchor ring, a steel casting attached to the interlining above and below, and intended primarily to serve as the lower anchorage for the special steel bolts which carry the lifting pressure against the cover. To insure the anchor ring being exactly horizontal and at the correct elevation,

the connection between it and the steel interlining was drilled after assembly in the shaft. The cast-steel cap or cover is a single casting, weighing 92,000 pounds, and having the following dimensions: maximum diameter at base, 16 ft. 11 in.; inside diameter corresponding with waterway, 14 ft.; rise on inside, 6 ft.; thickness varying from 3 inches at crown to 8 inches at base.

The cover rests on a cast-steel curb, and is held against this curb by 36–4½-inch diameter bolts of nickel-chrome steel, which extend down into the anchor ring about 50 ft. below. A special gasket is provided at the junction of the cover and curb. All bearing surfaces on cover and curb are machined, and nut seats spot faced. Each bolt is cased in a steel sleeve, 5 inches in diameter, made up in five sections; the top and bottom sections of cast-steel with projecting concentric ribs to insure a better bearing surface against the concrete, and with special machined ends to insure proper bearing against curb and anchor ring. The intermediate sections are of extra heavy steel pipe with special sleeve joints, calked with lead wool. The top and second sections are connected by a special screw coupling which permits final exact adjustment against the curb. The space around the 4½-inch bolts in the sleeves will be filled with oil to prevent corrosion. In addition the bolts are to be capped with bronze caps to protect their extremities from corrosion, and the bolt hole through the cover base is bronze lined for the same reason. The inside of the cover is protected by a 3-inch coat of mortar plastered over reinforcing metal attached to screw eyes located in tapped holes.

The bolt specifications called for

Tensile strength	100,000 lbs. per square inch
Elastic limit	80,000 " " " "
Elongation	20%
Reduction of area	45%

Tests of standard 2″x½″ bars from the ends of bolts indicated results considerably in excess of the above, and in addition one full sized bolt was broken in the testing machine at the Phoenix Iron Works, Phoenixville, Pa. Owing to limitations of the testing machine as to length of specimen tested, it was necessary to cut the bolt to a length of 20 ft. It failed under a total load of 1,716,000 lbs., or 107,000 lbs. per square inch. Each bolt weighs

bolts at the same time. The final stressing will not be attempted until the concrete under the curb has had time to age sufficiently.

After the cover is set the Moodna-Hudson tunnel will be subjected to hydrostatic test by filling with water to the elevation of aqueduct invert at Breakneck tunnel (approximately 400 ft. above the cover level).

A blowoff connection, 40 inches in diameter, is provided just under the cover for drawing down water in the terminal shafts. Under full pressure its capacity is that of the aqueduct, or 500,000,000 gallons daily, and the velocity through the nozzle under these conditions is about 100 ft. per second. The blowoff nozzle of cast-bronze is collar-bolted to the top ring of interlining, and water is controlled by two 40-inch valves hydraulically operated, the inside one of bronze and weighing complete 29,000 lbs., the other of cast-iron, and slightly heavier. A 12-inch bypass, controlled by two valves, is also provided, together with suitable piping for operating the cylinders on the 40-inch valves. The blowoff discharges into a concrete stilling chamber, where the velocity is reduced, and from the stilling chamber the water flows through a double concrete conduit into the Hudson river. A concrete chamber is built over the shaft, and over this will be built later an imposing superstructure. This superstructure, together with contemplated improvements along the adjacent river front, will remind passersby of what is popularly considered the most marvelous feature of New York's new water supply.

Operation

The most interesting detail in connection with the operation and maintenance of the Hudson tunnel will be the unwatering, which will be undertaken only when necessary for inspection or repairs. Preliminary to unwatering the tunnel the water in the terminal shafts will be drawn down through the 40-inch blowoff referred to above. The cast-steel cover will then be unbolted and moved to the chamber annex provided for its accommodation. Lifting attachments are provided on the cover, also track connection into the chamber annex to facilitate handling. The unwatering equipment will consist of a riveted steel float, 12 ft. 9 in. diameter, and 35 ft. in height, equipped with continuous angle iron guides which engaged the concrete guides in the shaft. This float will

the tunnel for purposes of inspection, also to test out the efficiency of the unwatering equipment under the difficult working conditions that will obtain.

The author wishes to record his indebtedness to former Department Engineer Robert Ridgway for material taken from a paper prepared by him for the Engineers' Society of Northeastern Pennsylvania, to Mr. Lazarus White for data obtained from his book on the "Catskill Water Supply," and to Mr. William B. Hoke, assistant engineer in immediate charge of the construction, for helpful suggestions in the preparation of this paper.

The work was carried out under the direction of Mr. J. Waldo Smith, chief engineer, Mr. Robert Ridgway, department engineer, Northern Aqueduct Department until January 16, 1912, and the writer as department engineer since that date, Mr. William E. Swift, division engineer, Hudson River Division to December 1, 1911, and Mr. Frank L. Clapp, acting division engineer since that date, and Mr. William B. Hoke, section engineer. All designs were prepared under the direction of Headquarters Department, Mr. Alfred D. Flinn, department engineer, this department also looking after the inspection of manufactured materials.

The best type of reinforcement to use is a wire mesh with the heavy strands running transversely across the road. The reinforcement is laid so that it does not cross the joints in the road.

The enormous increase in the yardage of concrete roads throughout the United States proves that its advantages are being rapidly recognized by highway engineers.

DISCUSSION.

CHAIRMAN.—It is generally considered among engineers that the concrete road is the ultimate solution of the road problem, but it has also been generally felt that it has been passing through an experimental stage, and most of them are willing to let the other fellow do the experimenting; but that stage is past, and the continued use of this road in the future will be marked.

MR. W. A. MCINTYRE.—I did not expect to say anything, but to open the discussion, I might state the fact that there are several other types of what may be called concrete roads other than those which Mr. Ferguson has mentioned. One consists in the laying of a macadam road without the binder course, and the addition thereto of a 1: 1 sand and cement grout. After the grout has been applied and before it has set the road is rolled. This is known as the Hassam pavement and bears the same relation to the concrete pavement that the penetration method in bituminous construction bears to the mixed method. This type has been in some cases a success, and in others not a success. The difficulty seems to be a lack of knowledge as to the amount of penetration obtained.

There is another class of pavement known as the Blome pavement; one type the Granitoid and the other the Granocrete. The first is marked off in 4½" x 9" blocks, with a base of a 1: 3: 4 mixture 5¼" thick. The top course is 1¾" thick made in the proportion of 1 to 1½. The aggregate in this course is of granite or other hard rock and is graded in size using 50% of ¼" size, 30% of ⅛" and 20% of ½". The top is placed within 30 minutes after the laying of the base. The granocrete type is practically of the same construction, but the surface is not blocked.

There are other modifications of the concrete pavement; one is known as Silica, and has been used only in Duluth; another is Vibrolithic, a 1: 2: 4 mixture, over which planks are placed before the concrete hardens. A motor set on wheels is moved back and forth over the planks causing vibrations which compact the concrete and according to the inventor reduce the coefficient of expansion and consequently fewer cracks should appear. The joints can therefore be placed further apart.

It may be interesting in this connection to note some experiments made in Washington, D. C., by the Office of Public Roads. Mr. Page, the director, laid about 4500′ of pavement without any joints whatever. Many engineers would say that such a pavement would buckle. Such a condition, however, did not arise. One section was laid with gravel as the coarse aggregate, another section with trap rock and a third with limestone. The contraction cracks in the gravel averaged 45 feet apart, in the trap rock 60 feet, and in the limestone 160 feet apart. There has, as yet, been no explanation as of why such a dif-

ference should occur with the different aggregates; all the sections were laid of the same consistency and by the same men in the same manner.

Mr. Ferguson brought out the fact that the sub-base must be as nearly perfect as possible. It must be absolutely smooth, so that there will be every opportunity for a free movement of the concrete after it has set. In this way only can we be assured that cracks will not appear.

CHAIRMAN.—Has the flat sub-base absolutely done away with the longitudinal crack?

MR. MCINTYRE.—No, not entirely. Probably 90% of the construction now is with the flat sub-base, and it has to a great extent cut down the longitudinal crack.

MR. W. C. FURBER.—Why is a concrete road not hard on horses' feet?

MR. FERGUSON.—A horse secures a very even and firm footing when he places his feet on a concrete road. On roads which are built of stone, the horse is likely to place his foot on a loose stone, which tends to throw it to one side or the other, straining his knee or his shoulder. The question of hardness is to a great extent a question of being accustomed to a given type of road. You do not hear any complaints of brick or belgian blocks being too hard. I think Delaware avenue is paved with belgian blocks, and many of the streets in New York are paved with belgian blocks where they have the heaviest traffic, and no one complains of hardness. It is not so much a question of hardness as it is of the horse being able to place his feet on an even surface. So many of our surfaces are constructed with an excessive crown that it is almost impossible to drive horses over them with safety.

MR. E. M. NICHOLS.—Do you not think the speed of the animal has something to do with it, as well as the surface?

MR. FERGUSON.—Perhaps the speed of the animal has had something to do with it. You might have noticed, however, in one of the pictures I showed a horse turning the corner at a gallop. At Albany, New York, there is a concrete road. A man who has retired from business and spends most of his time driving fast horses uses this road a great deal, and stated that it was his experience that no injurious effects were suffered by horses traveling over it at a rapid gait.

MR. NICHOLS.—I imagine a horse would not go very fast over a block pavement.

MR. FERGUSON.—No, but the horse puts his feet down solidly and with great force. Horses travel at high speed over brick pavements. The high tractive resistance of a block pavement reduces speed.

A MEMBER.—Would not the less tractive effort required on a concrete road have something to do with it?

MR. FERGUSON.—Yes, it would have a great deal to do with it, and in that connection I have had some rather interesting experiences. Out in Wayne county a man, who was driving on a concrete road, was asked if he did not find that road injurious to the horses, and his answer was no, in no way whatever, and

that it was perfectly satisfactory. One farmer said, "I know it wears out the horses' shoes somewhat, but I now only have to have one horse to pull the same load that I used to pull with two, and I would rather buy shoes than horses."

It is quite interesting to go out and interview the men who are using these roads, and that is the best evidence of the advantage of any type of construction.

One of our engineers who was out on a section of concrete highway, had a university professor with him, and this professor was making very careful notes of the answers to the questions put to the men who drove along the roads. The first one interrogated replied that they were perfectly satisfactory, and four or five others gave the same answer, until the professor turned around and said, "I guess you have the whole bunch fixed."

CHAIRMAN.—Would you not always put a longitudinal joint in a 40-ft. road?

MR. FERGUSON.—No, not necessarily. There have been 40-ft. wide roads built. The best practice is to use reinforcement when the road is over 25 feet wide. If near that width the main body of the concrete can be narrowed by building a wide gutter.

MR. ALLEN.—How far apart do the cracks come—the transverse cracks?

MR. FERGUSON.—That depends upon the condition of the sub-base and the strength of the concrete. The transverse cracks come naturally anywhere from 45 to 160 feet apart. These cracks, however, after a year's use, when filled with tar, give no trouble at all and produce an even and satisfactory surface.

A MEMBER.—Is there not any serious wear on concrete roads which have been used for a number of years?

MR. FERGUSON.—I would not say there is no wear, but a number of concrete roads after years of wear are in perfect condition. I have seen concrete roads that have been used for five years without any steel plates at the joints which are in perfect condition today.

MR. NICHOLS.—With no appreciable wear?

A.—There has been about 1-16", that is all.

MR. S. M. SWAAB.—Would you recommend it as a pavement for a city street.

A.—It depends upon the character of the traffic that goes over it. Under certain classes of traffic you must put down some kind of surface that can be replaced as fast as it wears out, supporting it on a firm foundation.

MR. SWAAB.—I am looking at it more from the point of view of the repairs. It may be necessary to take up the street for drainage and other things, and have to repair it afterwards.

A.—We do that right on Broad street every day.

MR. SWAAB.—It would be hard to dig up a trench and in putting it back get the sub-base absolutely level.

A.—I have seen many concrete streets where patches have been made. If you will make a patch intelligently by taking all the loose material from the edges of the fracture and scrub the surface thoroughly to remove every particle of dust, and then wet it before the fresh concrete is placed, it is difficult after a year's wear to find out where that opening had been made.

Mr. Carney.—We have been making some roads with joints at different distances apart. Suppose you have a short length, could you determine what length it was necessary to put the joints apart?

Mr. Ferguson.—I think the only way is to try different lengths. So far experience shows that a spacing of from 25 to 35 feet is best.

Chairman.—That Bethayres road is in use now; has it developed any cracks?

Mr. Ferguson.—It did before the bituminous surface was spread on the concrete. I hope that as fast as any patches wear off it will be replaced, so that the road will continue in good condition. Especially should this be done at the cracks.

Mr. Allen.—What is the effect of laying a concrete road when the ground is frozen.

A.—We do not do that.

Mr. Allen.—I read an article in the Good Roads Bulletin written by Mr. Green about the Wayne county roads—are you familiar with that article?

A.—Yes.

Mr. Allen.—It speaks of cracks that have to be filled every six months.

Mr. Ferguson.—The best answer to Mr. Green's article is, that this year there were constructed in Wayne county 30 miles of roads, and the people gave the commissioners more money than they could spend for further extensions. They are more than satisfied with what they are getting. The same commissioners have been reelected several times since they started to build concrete roads.

Mr. Allen.—Have you seen the Wayne county roads?

A.—I have seen every one of them.

A Member.—Is that stretch of road between Mount Clemens and Detroit concrete, and has it disintegrated?

Mr. Ferguson.—Woodward avenue extends out from Detroit through Wayne county and into the next county. The work of the Wayne county commissioners stops, of course, at the edge of their county. The adjoining county has a bituminous macadam road, laid last year as an extension from the concrete. This macadam, built in 1912, has disintegrated very badly. I think that is what you must refer to

Mr. McCrudden.—Have you any successful concrete roads in the vicinity of Philadelphia?

A.—There is one in Chestnut Hill, built about four years ago. The other road I had reference to is on the Morris turnpike, in Warren county, New Jersey, built about one and a half years ago. Within the last few months there has been one finished at Beth Ayres. The one at Chestnut Hill is of the Hassam type.

CHAIRMAN.—What do you consider the maximum grade on which this concrete surface can be laid on an ordinary country road?

A. It is difficult to say; the Warren county road has a 6% grade. In Connecticut we have just finished a road with an 8% grade. We have another with a 14% grade. At the bottom of this steep grade there is brick paving on an 8% grade. The horses travel easily over the concrete, but as soon as they strike the brick they have difficulty in keeping a foothold. As a matter of fact I do not like to see much over a 7% grade.

A MEMBER.—How would you provide for transverse expansion and contraction on a curve?

MR. FERGUSON.—With radial joints about ¼" wide filled with some kind of elastic material. I spoke of the shrinkage of concrete—concrete contracts in setting about as much as would be caused by a reduction in temperature of 114°. When a concrete road shrinks and forms joints, the joints, under traffic, fill up slightly with smaller particles, and when the concrete expands again it cannot take full advantage of the amount of contraction that has gone on in it. We, therefore, construct artificial joints ¼-inch wide and fill them with some kind of elastic material.

A MEMBER.—Is it of advantage to add oil to the concrete?

A.—No. Mr. Page did so, but I think his idea was that it would reduce the number of transverse cracks.

CHAIRMAN.—Was not his idea to add resiliency too?

MR. FERGUSON.—That was his idea also.

MR. NICHOLS.—You were speaking of the irregularity of the transverse cracks in that street. Don't you think the method of mixing the concrete has had as much to do with it as anything else? There can be quite a variation in the proportions, even with ordinary care in mixing.

MR. FERGUSON.—Yes, that is so. Particular care must be exercised in securing proper proportions and proper mixing. In many instances concrete mixers have measuring tanks for water. Even the amount of water in each batch should be the same.

MR. NICHOLS.—Will there not be more in one batch than in others? Assuming you have the exact proportions in each batch, is there not apt to be some variation between the batches owing to the method of handling?

MR. FERGUSON.—There are not any more variables entering into the construction of a concrete road than there is in the asphalt wearing surface.

Mr. J. C. Wilson.—What sort of a county is this Wayne county that can afford to build those 90 miles of roads?

Mr. Nichols.—It is where they build the Ford automobiles.

Mr. Wilson.—The bonds on roads, I understand in many cases, last about five times as long as the roads do. The question is in reference to an ordinary community, how they can afford to lay cement roads and how they can afford to keep on laying macadam roads—for the reason stated, that they give out too fast. As I understand the figures, the cement road costs about 25% more than the macadam road. Is that right?

Mr. Ferguson.—A little bit more than that. You can build an ordinary macadam road for about 85c per square yard. A concrete road costs about $1.25 per square yard.

Mr. Wilson.—Then the maintenance can almost be included in the concrete road.

Mr. Ferguson.—That is one point we make.

Mr. Silliman.—Would you recommend a concrete street for a street like our Tioga street, for instance, 26 feet between curbs? With no street car tracks on it? If so, what sort of mixture would you use, and what thickness of concrete would you advise, and would you advise putting a bituminous surface on that concrete. Also what arrangement of expansion joints?

Mr. Ferguson.—In answer to the first question, I would recommend concrete for that street.

As to the thickness, I think that a thickness of 7″ in the center and 5″ at the side would be sufficient. For a 26-foot street I would use reinforcing. As far as tearing up the street for public utility purposes is concerned, a concrete street can be patched as well as any other street. It simply requires more care and more ability on the part of those in charge of the roads; more inspection of the work actually being done.

A Member.—Is the life of concrete paving any more than ten years?

A.—It is when properly constructed.

Mr. Carl Hering.—In what way does a concrete road give out?

A. If the slight amount of maintenance work necessary is not done on a concrete road, wear will occur at the joints and holes are likely to form here. The life of the road will depend upon its original construction to a great extent.

A Member.—Is that Baker plate entirely discontinued now?

Mr. Ferguson.—No, it is very popular.

The installing device used with Baker plates consists of a T iron which spans the road and rests on the side forms. In the bottom flange of this T there are lugs. The plates with tar paper or felt between them are clamped securely between the lugs before placing in position in the road. The installer is bent

to the crown desired and the plates are therefore held in the proper position that their top edges are flush with the finished surface of the pavement. soon as the concrete becomes sufficiently firm the lugs are loosened and the iron removed.

MR. ELCOCK.—The speaker made reference to the engineer corps walking the Selinsgrove road. I had the pleasure of walking on that road, and it seem to fill every requirement. There were some surface cracks filled with tar. Cou you tell us when this road was built?

A.—In 1911.

MR. SCHMITZ.—What is the cost of the Baker plate per square yard?

A.—About 6 or 7c per square yard.

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, September 20, 1913

The meeting was called to order by President Taylor at 8.20 p. m., with 97 members and visitors in attendance. The minutes of the business meeting, held June 7, 1913, were approved as printed in abstract.

The Secretary announced that the Board of Governors, at their meeting on September 18, had elected the following:

To Active Membership—Guilliaem Aertsen, Robert E. Carney, Charles F. Puff, Jr., and Edmund F. Saxton. To Associate Membership—Lee Terhune Ward.

The President announced that with the money donated by the Junior Section new books had been purchased for the library, which were now on the shelves and formed a very valuable addition to the library.

Mr. Charles F. Mebus presented the paper of the evening, entitled, "Sewage Treatment in Pennsylvania," which was discussed by Dr. Henry Leffman, John C. Trautwine, Jr., and Emile G. Perrot.

Mr. John C. Trautwine, Jr., explained the theory of water hammer, which was discussed by Henry E. Birkinbine, Dr. Henry Leffman and P. A. Maignen.

Regular Meeting, October 4, 1913

The meeting was called to order by President Taylor at 8.35 p. m., with 78 members and visitors in attendance. The minutes of the regular meeting, held September 20, 1913, were approved as printed in abstract.

The President announced on behalf of the House Committee that instead of the usual annual Smoker, a monthly Smoker would be held, on the fourth Saturday evening of each month, the first monthly Smoker would be held on October 25, 1913, to which all members and their friends are cordially invited.

Mr. W. G. Button presented the paper of the evening, entitled "The Limitations of Mathematical Theory Applied to Engineering," which was discussed by John C. Trautwine, Jr., Manton E. Hibbs, Henry H. Quimby, Henry Leffmann, W. P. Taylor, S. M. Swaab, John G. Brown and Carl Hering.

A unanimous vote of thanks was extended to Mr. Button.

Business Meeting, October 18, 1913

The meeting was called to order by Vice President Swaab, at 8.30 p. m., with 173 members and visitors in attendance.

Dr. Henry Leffman presented the paper of the evening, entitled "Modern Color Photography," which was discussed by Mr. Henry Hess.

Regular Meeting, November 1, 1913

The meeting was called to order at 8.30 p. m. by President Taylor, with 68 members and visitors in attendance.

The minutes of the meeting of October 18, 1913, were approved as printed in abstract.

Mr. Bernard J. Newman, Secretary of the Philadelphia Housing Commission, presented the paper of the evening, entitled "Colossal Waste Due to Bad Municipal Engineering," which was discussed by President Taylor, B. A. Haldeman, W. C. Furber, C. F. Puff, Jr., S. M. Swaab, John C. Trautwine, Jr., and Fritz Bloch.

A unanimous vote of thanks was extended to Mr. Newman for his excellent paper.

BUSINESS MEETING, NOVEMBER 15, 1913

The meeting was called to order at 8.30 p. m., by President Taylor, with 112 members and visitors in attendance. The minutes of the meeting of November 8th were approved as printed in abstract.

The Committee on Nominations presented the following nominations for officers of the Club for the year 1914: President, S. M. Swaab; Vice President, J. A. Vogleson; Secretary, H. L. McMillan; Treasurer, J. Reese Bailey; Directors, J. H. M. Andrews, E. J. Dauner, F. C. Dunlap, Henry Hess.

The Secretary announced that the Board of Governors had elected to membership the following: Active—Herman E. Beyer, L. L. Gerstenberger, Charles R. Weiss; Associate—J. Hansell French, Thos. F. McBride; Junior—Charles G. Thornburg.

Mr. George A. Harwood, Chief Engineer, N. Y. C. & H. R. R. R., presented the paper of the evening, entitled, "The Grand Central Terminal Improvements," which was discussed by Messrs. John C. Trautwine, Jr., W. Copeland Furber, E. B. Temple.

A unanimous vote of thanks was extended Mr. Harwood for his excellent paper.

BUSINESS MEETING, DECEMBER 6, 1913

The meeting was called to order by President Taylor, at 8.30 p. m., with 117 members and visitors in attendance.

Mr. Ralph N. Wheeler, Division Engineer, Board of Water Supply, New York, presented the paper of the evening, entitled "The Hudson River Crossing of the Catskill Aqueduct." A unanimous vote of thanks was tendered Mr. Wheeler for his interesting and instructive paper.

BUSINESS MEETING, DECEMBER 20, 1913

The meeting was called to order at 8.30 p. m., by President Taylor with 165 members and visitors in attendance.

The Secretary announced that the Board of Governors, at their regular meeting on Thursday, December 18, 1913, had elected the following to membership: Active—Stephen H. Noyes, Herman V. Schreiber, A. M. Van Osten; Junior—Henry Voigt, Ragnar E. Hasselgren, Conrad W. Hallowell.

Mr. Lewis R. Ferguson, Assistant Secretary of the American Portland Cement Manufacturers, presented the paper of the evening, entitled "Concrete Roadways," which was discussed by Messrs. W. P. Taylor, J. S. McIntyre, L. T. Ward, H. C. Berry, R. E. Carney, E. M. Nichols, J. C. Wilson, F. Bloch.

ABSTRACT OF MINUTES OF THE BOARD

REGULAR MEETING, SEPTEMBER 18, 1913

Present: President Taylor, Vice President Plack, Directors Gilpin, Vogleson, Berry, Haldeman, Yarnall, Hibbs, Snook, Worley, the Secretary and the Treasurer.

The minutes of the regular meeting of May 15th and the special meeting of June 19th were read and approved.

The Secretary reported the death of Mr. R. A. Shillingford, and the Treasurer was instructed to charge off his dues for the last half of 1913.

The Treasurer reported a net gain to September 1st of $2,493.99, as compared with $862.39 for the same period of 1912.

The House Committee's report was read and approved.

An appropriation of $150 was made to the House Committee for the purpose of holding a "Club Night" in the months of October, November and December.

The Meetings Committee reported the schedule of meetings for the coming season.

The Membership Committee's report was presented and the following were elected: To Active Membership—Guilliaem Aertsen, Robert E. Carney, Charles F. Puff, Jr., Edmund F. Saxton; to Associate Membership—Lee Terhune Ward.

Mr. C. A. Bockius was transferred from associate to active membership.

Reports of the Publication and Library Committees were read and approved.

The privileges of the Club were extended to the American Mining Congress, during their session in Philadelphia, October 20th to 24th; to the American Institute of Electrical Engineers, during the week of October 13th; and to the National Fire Prevention Convention, during the week of October 13th.

The Treasurer reported that the following had been dropped from the roll for non-payment of dues: J. Frank Barber, E. H. Greenwood, A. L. Hallstrom, John G. Hendrie, L. J. F. Moore, William Oram, W. J. Pollock, T. J. Reilly, J. A. Remon, M. D. S. Stiles, H. G. H. Tarr.

REGULAR MEETING, NOVEMBER 13, 1913

Present: President Taylor, Vice Presidents Swaab and Mebus, Directors Develin, Vogleson, Berry, Haldeman, Yarnall, Gibson, Hibbs and the Secretary.

The minutes of the regular meeting of September 18th were read and approved.

Reports of the Secretary and Treasurer were read and approved.

The House Committee's report was read and approved.

The Membership Committee's report was read and the following were elected: To Active Membership—Herman E. Beyer, L. L. Gerstenberger, Charles R. Weiss; To Associate Membership—J. Hansell French, Thomas F. McBride; To Junior Membership—Charles G. Thornburg.

Report of the Meetings Committee was read and approved.

The Publication Committee presented a sample copy of material to be incorporated in the Club bulletin, and after discussion, the Committee was authorized to publish this bulletin for the next three months in place of the regular semimonthly notice.

The report of the Publicity Committee was read and approved.

A communication from E. H. Zieber, former Junior member of the Club, was presented, in which he asked reinstatement, and the Board passed a resolution, reinstating him to membership upon the payment of dues which have accrued since his resignation went into effect.

The resignations of C. Willis Adams, Arthur F. Barnes, Allen S. Hurlburt, R. W. Hilles, H. D. Elfreth and G. W. Whiteman were accepted as of December 31, 1913.

The Treasurer reported that the following had been dropped from the roll for non-payment of dues: Geo. F. Smith, Lorenzo S. Cope, W. M. Karekin.

J. A. Vogleson and S. M. Swaab were appointed a committee to represent the Engineers' Club on the committee to make arrangements for a meeting of the various technical societies of Philadelphia and vicinity.

Regular Meeting, December 18, 1913

Present: President Taylor, Vice Presidents Plack, Mebus and Swaab, Directors Develin, Vogleson, Haldeman, Yarnall, Gibson, Snook and the Secretary and Treasurer.

The minutes of the regular meeting of November 13th were read and approved.

The Secretary reported the resignations that were before the Club and the following were accepted as of December 31, 1913: John Gwilliam, F. Thibault Gross, J. A. P. Crisfield, Charles Wirt, J. F. Buchanan, Carl H. Satherberg, Charles Wilke, David Halstead, Thomas L. Latta, Martin Stotz, G. N. Dawes, A. L. Terry, Jr., C. N. Butler, A. T. Lewis, F. F. Dickerman, Martin Nixon-Miller, Harrison Souder, C. C. Willits, George F. Pond, W. S. Evans, E. H. Robie

The Treasurer reported a net gain of $2,592.29, as compared to $1,217.32 for the same period of 1912.

Reports of the following committees were presented and approved: House, Membership, Publication and Library.

The following were elected to membership: Active—Stephen H. Noyes, Hermann V. Schreiber, A. M. Van Osten; Junior—Henry Voigt, Ragnar H. Hasselgren, Conrad W. Hallowell.

On motion the following Junior members were transferred: To Active Membership—Edward N. Blum, C. N. Wunder, S. H. Wright, Chas. H. Schaefer, John C. Graf; To Associate Membership—Victor Shuman, James E. Diamond.

The following resolution was proposed by Mr. Gibson, seconded by Mr. Bailey and carried:

"In consideration of the cancellation of an existing contract with Mr. Ritchie, and in settlement of all agreements due him, that he be paid the sum of $500, in addition to his present salary, which is due him under his contract of May 1, 1912, and which shall include all indebtedness due him to January 1, 1914; and that a new contract be made, under date of January 1, 1914, paying him at the

rate of $2,100 per annum, to be payable in instalments of $175 per month, and that the President and Treasurer be empowered to put this motion into effect in the proper form."

The Business Manager was ordered to look up the correspondence in connection with the Evans Studio, and if there was no agreement existing between the Engineers' Club and the Evans Studio, authorizing them to use our name upon their stationery, that they be ordered to remove it therefrom.

A communication from the News Distributing Company, in reference to publicity, was presented by Mr. Hess and referred to the Publicity Committee for report at the next meeting of the Board.

Mr. Hess, as delegate to the International Conference of Safety and Sanitation in New York City, reported the result of his visit to the Conference.

Mr. Vogleson reported the results of the meeting of the Committee of Allied Societies of Philadelphia.

The Treasurer reported that Erle C. Herman had been dropped from the roll in accordance with Act VII. Sec. 1, of the By-Laws.

Modern Electric Supply Station," which was discussed by Messrs. W. C. L. Eglin, A. C. Wood, W. C. Kerr, and Thomas C. McBride.

A unanimous vote of thanks was tendered Mr. Moultrop.

REGULAR MEETING, MARCH 21, 1914

The meeting was called to order by Vice President Mebus at 8.30 p. m., with 67 members and visitors in attendance.

Mr. John Birkinbine presented the paper of the evening, entitled "A Hydro-Electric Development on the Tallulah River, Georgia," which was discussed by Messrs. J. C. Wilson, John C. Trautwine, Jr., E. U. Gibbs, and Drs. Hering and Chance.

December 20.—"Concrete Roadways." Le
tary, American Portland Cement Manufactur

FINANCIAL REPORT FOR T

STATEMENT OF ASSETS AN

as of December 3

Assets

Cash—Colonial Trust Co.—Active Account..
Colonial Trust Co.—Interest Account.
In Office.........................

Accounts Receivable................ ...
*Building Fund Notes, special fund.........
*Second Mortgage Bonds, special fund......

*Sinking Fund for Redemption of Second Mo
Regular Account.........................
Interest Account, special fund............
Principal Account, special fund...........

*In hands of the Trustees for the Redempti

Inventory of Supplies on H

Wines and Liquors. ... .
Restaurant Provisions .....
Cigars .. ..
House Supplies . .

Fuel . ...

Property

Building No. 1317 Spruce Street . ...
Furniture and Fixtures—House
Furniture and Fixtures—Restaurant
Library. . .. .

Insurance

Perpetual on Club-house .
Employer's Liability........ . ...

Miscellaneou

J. Reese Bailey, Treasurer...... . ...

Total Assets ... . . .

Liabilities

Accounts Payable			$ 3,583.54
Bills Payable, Building Account			7,950.00
Trustees for the Redemption Fund of Second Mortgage Bonds:			
Note, special fund		$ 3,250.00	
Second Mortgage Bonds, special fund		200.00	
			3,450.00
First Mortgage Payable		$40,000.00	
Second Mortgage Bonds		25,250.00	
			65,250.00
Accrued Interest—First Mortgage		$ 1,080.00	
Accrued Interest—Second Mortgage Bonds		1,802.50	
Accrued Interest—Building Fund Notes		150.47	
			3,032.97
Appropriation from Junior Section to Library Committee			.68
Library Fund			10.00
Link Belt Co., 2d Mortgage Bond Account			178.35
Total Liabilities			$83,455.54

Capital (Surplus) Account

Surplus, January 1, 1913		$ 12,647.54	
Adjustment of Perpetual Insurance	$ 178.20		
Balance of Manager's Salary for 1912	200.00		
Suspense Account, Uncollectable Accounts	953.27		
		1,331.47	
		$11,316.07	
Reserve for 2d Mortgage Bonds	$ 36.20		
Unexpected Returns	155.00		
		191.20	
		$11,507.27	
Gain for 1913, as per Statement of Income and Expense		2,671.41	
Surplus as of December 31, 1913			$14,178.68
			$97,634.22

STATEMENT OF INCOME AND EXPENSES FOR THE YEAR 1913

INCOME

Dues—Net	$16,515.00	
Initiation Fees	1,470.00	
		$17,985.00

Publications

Advertising—Directory		$ 390.00	
Advertising—Proceedings		627.55	
Sales—Directory		1.00	
Sales—Proceedings		73.43	

Miscellaneous

Badge Sales		$ 18.25	
Interest on Deposits, Active Account	$ 28.11		
Interest on Deposits, Interest Account	9.36		
Interest on Sinking Funds	9.17		
Interest on Building Fund Notes, special fund	79.89		
Special fund	10.00		
		136.53	
Telephone Receipts		136.4	

Club-house Business

Billiard and Pool Sales		$ 260.40	
Cigar Sales		2,272.46	
Lodging		3,687.44	
Rent of Meeting Room		623 00	
Restaurant Sales		6,991.50	
Restaurant Sales, Meals of Employees		2,232.00	
Wine Sales		1,305.58	17372.
Total Income			$36,740.

EXPENSE

Salaries and Wages

Manager		$ 2,100 00	
House, Salaries and Wages	$2,560 32		
House, Meals of Employees	720 00		
		3,280.32	
Office, Salaries	$1,919 72		
Office, Meals of Employees	432 00		
		2,351.72	
Restaurant, Salaries and Wages	$2,896 46		
Restaurant, Meals of Employees	1,080 00		
		3,976 46	
			$11,708.

Expense

House Expense		$ 1,147.37	
Office Expense		642.93	
Directors' Expense		30.00	
Library Expense		61.30	
			1,881.

Publications

Directory Publishing		$ 315.94	
Proceedings Publishing		1,169.72	
			1,485.66

Miscellaneous

Badge Purchases		$ 11.00	
By-Laws Revision		140.90	
Club Lucheons		360.00	
Entertainment Committee, New Year's Day	$ 38.33		
Entertainment Committee, Reception	229.53		
Entertainment Committee, Smoker	150.00		
		417.86	
Excess and Deficiency Account		1.05	
Extraordinary Expense, House Account		354.08	
Fuel Purchases	$ 454.12		
Inventory, January 1, 1913	26.12		
	$ 480.24		
Inventory, December 31, 1913	32.48		
		447.76	
Gas and Electricity		1,286.03	
Insurance Expense		65.58	
Meetings Committee		433.60	
Membership Committee		75.65	
Nominations Committee		9.20	
State Tax on Second Mortgage Bonds		101.00	
Taxes and Water Rent		943.00	
Telephone Expense		389.21	
Trustees of Sinking Fund		3.00	
			5,038.92

Interest

Interest on First Mortgage		$ 2,160.00	
Interest on Second Mortgage Bonds		1,262.50	
Interest on Building Fund Notes		422.86	
			3,845.36

Club-house Business

Billiards and Pool Purchases	$ 8.90		
Cigar Purchases	1,990.53		
Wine Purchases	1,099.57		
		$3,099.00	
Restaurant Expense	$ 873.69		
Restaurant Provision Purchases	6,177.65		
		7,051.34	
		$10,150.34	

From information as to amount and direction of traffic and knowledge of general conditions affecting cost of construction and, having considered strategic position, then a tentative location can be considered. If the country is rather rough, a survey of one or more routes may be advisable; if it is comparatively level, the survey may be postponed; when to make survey also depends on time available, the season of the year, and other factors, including advisability of appearing to be busy, and of surveying more than one route in order to obtain interest and competition. This is about the only time when anything will be "given" to the road.

Tentative Plan

The tentative plan will be based on such ruling and maximum grades as the engineer's experience indicates to him will probably prove, after further examination, to be about right, considering magnitude and direction of traffic, topography, etc. Carried along with considerations of locations, grades, etc., will be preliminary studies of the equipment which will be necessary to handle the traffic, and the character of service best fitted to the conditions, and the general type of equipment best suited to the service to be given.

Tentative train sheets should be prepared and comparative advantages and disadvantages tabulated. Effect on platform charges (exceedingly important), effect on total and maximum peak power (as to each substation and as to power house), location of passing points, relation of same to grade, meeting at central points in town, and whether advisable or not, and other items.

The location of power house and sub-stations, of car shops, etc., requires careful consideration.

The business probably obtainable for each class of service—passenger, express, freight, mail, should be estimated on an annual basis, and also monthly. In some cases, the sale of power and light may be contemplated, but these items should be separated from receipts from railroad operation. The probable rates obtainable, expense of operation, including financial and all charges, total investment and net income for the second, fifth, and tenth year of operation, or some other future periods, must be predetermined with the greatest care.

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Fig. 5. Headway proposed for a Road of somewhat Unusual Character.

The preceding paragraph applies to Public Service Properties and also to manufacturing or other producing properties, the fundamental questions are "What and why—now and future?"

STATISTICS

For detailed statements, curves, etc., relative to
in connection with interurban electric railroad, see
Roberts, "Electric Railways in Sparsely Settled
Trans. A. E. Ry. Assn., Oct., '06.

Lantern slides were presented to illustrate point
the paper.

terminal city and the nearby town
ing, at noon, and late in the after
balance of the time two hourly.

The through passenger service a
for the rural section is not expecte
four hour headway is provided.
central section will be freight—live
and coal, in train lots. The outg
side of the center and go to the near
service provides a clear track for
grades are also designed to favor th

Relative to the consulting engine
figures, slides were shown of data
such purpose, and showing in deta
job."

Also the advisability of systemat
of preparing alternative plans was

A map of a road and the tributar
presented, and how to ascertain
territory and how to evaluate sam
of rivers, high hills, etc., pointed o
passenger service on same, its inad
pay such roads to materially improve same.

Other slides illustrating the visualising of plans, ascertaining
cause and effect as affecting traffic, etc., were presented.

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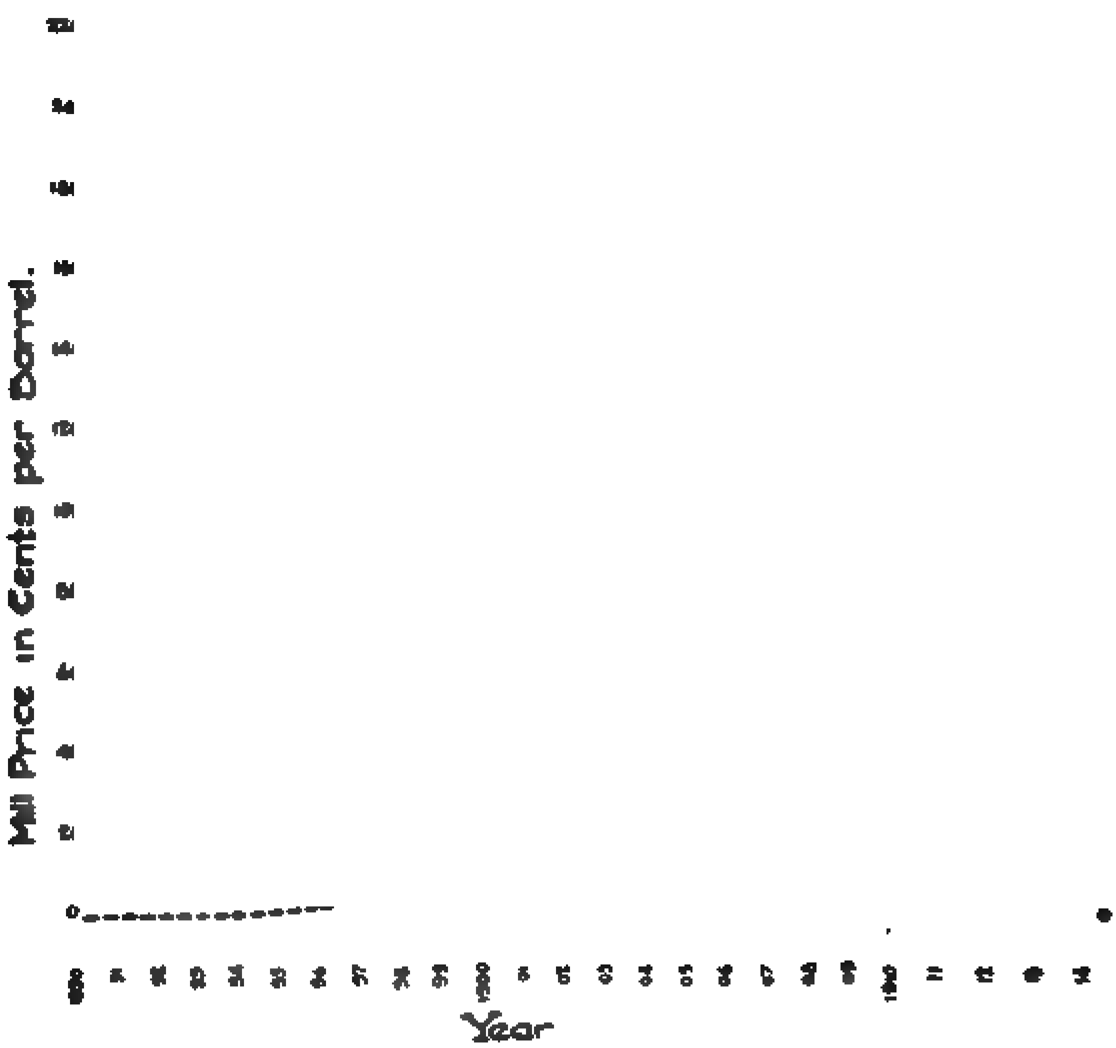

FIG. 1. Chart of Production and Average Mill Price for Cement Manufactured in United States.

have their effect on shifting the ratio of the various charges. However, a fair average of a modern mill may be expressed as follows:

Manufacturing labor	21%
Maintenance and repair labor	7%
Supplies	15%
Coal	27%
Office and miscellaneous charges	4%
Power	26%
	100%

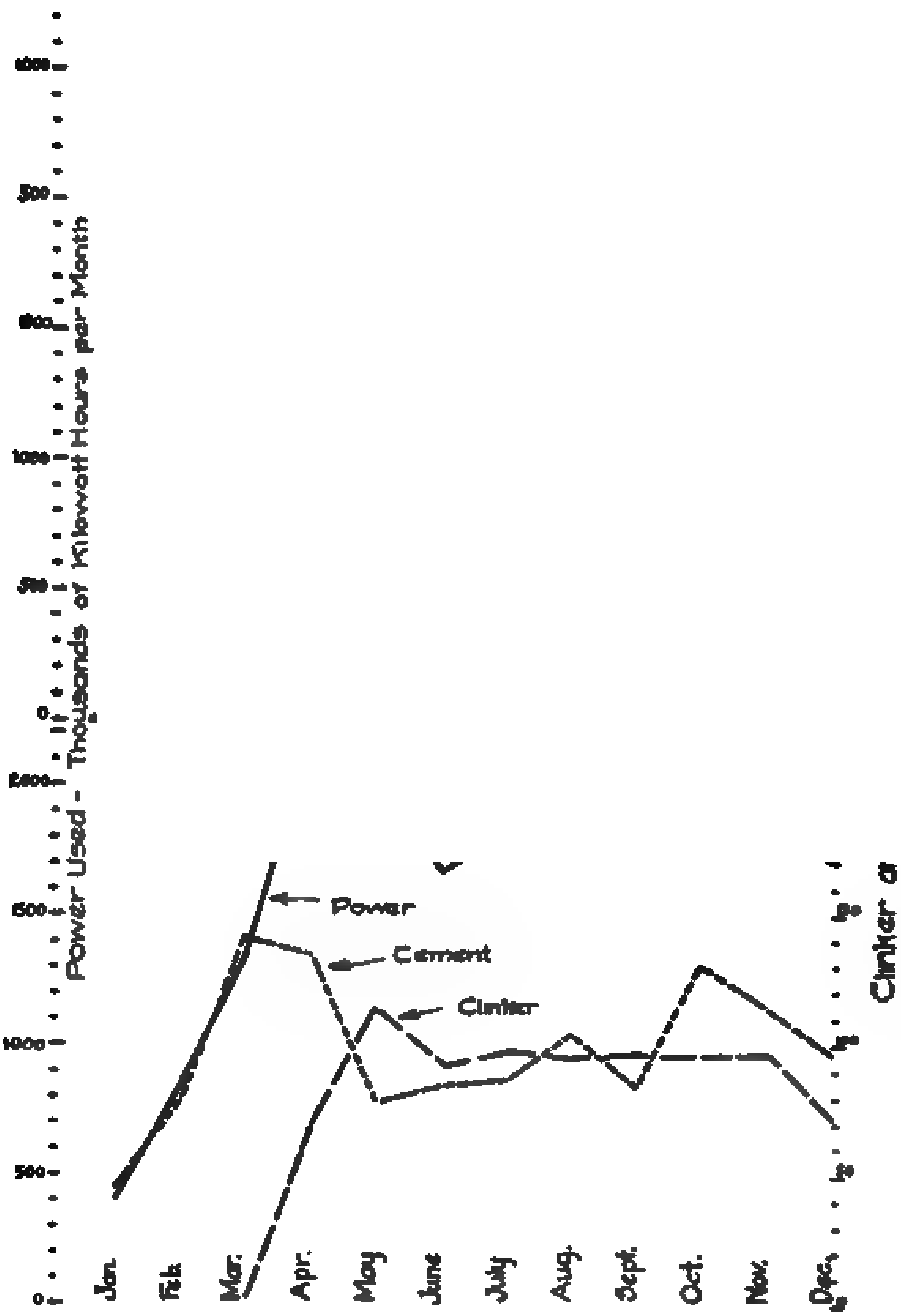

Fig. 3.—Chart of Typical Power

is almost impossible to maintain the speed on the machines at the most efficient point throughout the entire mill. The correction of

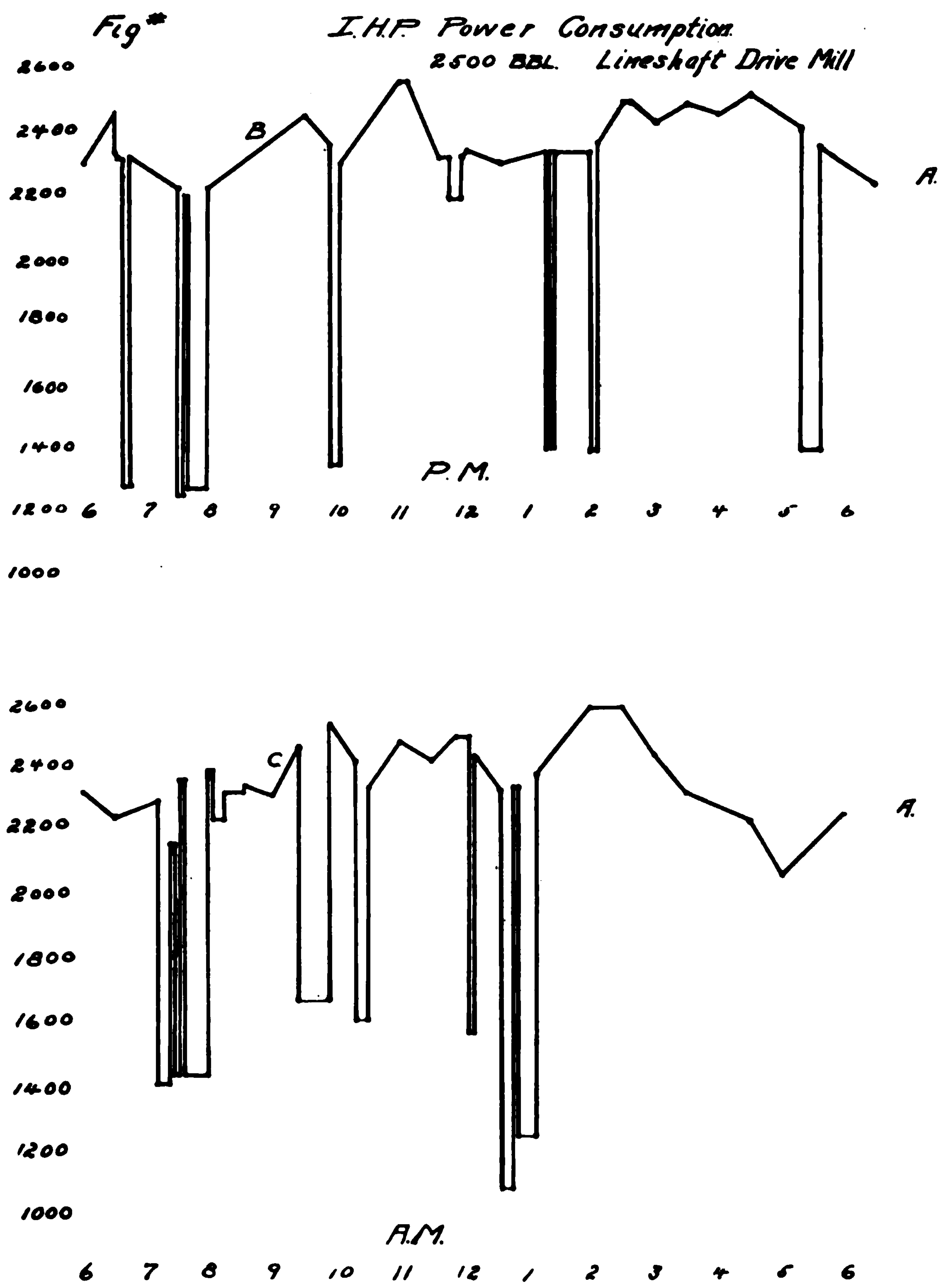

FIG. 11.—Typical Power Consumption Chart in a Line Shaft Driven Mill Chart made from a Series of Indicator Cards taken on the Various Engines at short intervals.

this feature will, as a general rule, increase the output from five to fifteen per cent.

the high-class talent of the plant. Thus things are observed and remedied which otherwise would be left to the repair gang's good mercies.

At this point, I wish to bring out one point which has been called to my attention. This plant had a poor power factor. This was largely due to the fact that a number of the early type of slow speed vertical motors were used. In fact, this is one of the first plants to be equipped with this form of motor. Many of the defects in the early types were eliminated in the newer motors due to co-operation between the plant management and the electrical manufacturers. In this case the power factor was not a serious item as the generators and distribution cables had ample capacity to take care of the extra current. The load factor on the contrary was very good and this has probably been confused in the lay mind with the other term, which is of less importance.

It may be said that this is all very well in a new plant, but how about a plant now operating with a line shaft drive? Will it pay to make the change?

The situation should be carefully analyzed and comparisons made with electrically driven plants. There is very little doubt that money wisely expended for electrical equipment will pay a much better rate of interest than the investment in the plant as a whole. In many cases the saving per year would amount to as much as 50% of the investment required for making the change.

First 5,000 K. W. H.....
Next 95,000 K. W. H. .
Above 100,000 K. W. H

The demand charge will be shown
noted that the greater portion of the
the basis of the minimum contract de
K. W. H. charge added to the deman
for power for each month. While t
the power consumption it does not
This is shown by Curve D, which give
for each month. This varies from a
mum of .707c per K. W. H. with an average cost of .857c per K. W. H. for a total of 19,736,000 K. W. H.

Figure 6 gives a similar set of curves for ten months' operation on another plant which used the power demand to better advantage. It will be noted that the variations in demand as shown by Curve A were much less. The demand charge in Curve B was greater than the contract minimum for one month only. The cost per K. W. H. varied very much less. The maximum being 1.57c and the minimum .715c. The average cost per K. W. H. was .805c for a total of 8,023,870 K. W. H.

In comparing the two plants, it will be noted that the second plant while using less than half the power of the first actually bought its power 052c per K. W. H. cheaper. Had the first plant operated in a similar manner it should have reduced its power bill by $10,263, or 11.6%. In reality, the average price should have been considerably lower than the cost for the smaller plant. Both plants could have materially reduced the average cost for power by utilizing their clinker and cement storage capacity to the fullest extent.

These notes, covering the general power situation in the Lehigh district with suggestions on power costs, are presented with a view toward aiding those interested in the problem of reducing the manufacturing costs. The savings secured by economical use of purchased power emphasizes the importance of a uniform power demand in order to obtain a minimum power cost. The methods of determining these costs are radically different from those in vogue in individual plants. The usual form of power contracts are clear to those familiar with this class of work, but are at first

somewhat confusing to the average mill superintendent. To get the lowest ultimate cost all elements must be carefully weighed and balanced and the mill operated in such a manner that this balance will be maintained.

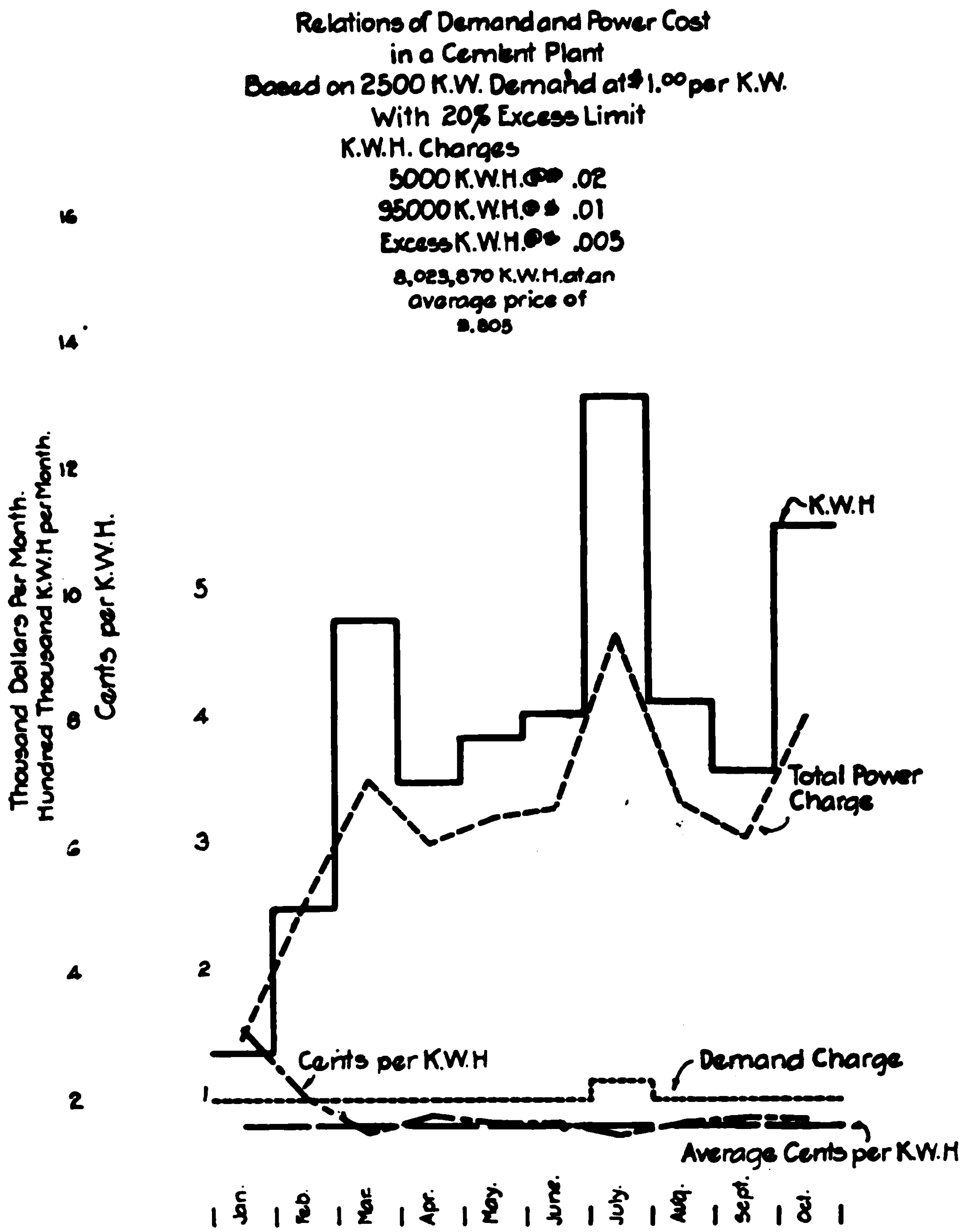

FIG. 6.—Chart of Relations of K. W. H. Consumption and Power Costs in a Cement Mill.

The following were elected to constitute the Committee on Nominations for the coming year:

Carl Hering, Richard Gilpin, Richard L. Humphrey, Thomas C. McBride, H. E. Ehlers, H. H. Quimby, R. G. Develin; Alternates, E. M. Evans, W. P. Dallett, George W. Hyde, George T. Gwilliam.

The resignation of Mr. Theodore W. Pinard was accepted.

The Membership Committee presented its report and the following were elected: To Junior Membership, Adam Cooper Warfel and Jordan Homer Stover; to Active Membership, Frederick Lennig.

The Treasurer reported a net gain to May 1st of $24.98, as compared to $1,790.19 for the same period of 1913.

The Treasurer was authorized to purchase a Universal adding machine for the Club office.

The report of the Committee on By-Laws was presented and accepted.

The questions of providing a booth for moving picture machine and the placing of awnings on the front of the house was referred to the House Committee, with power to act.

On motion, the following resolution was passed:

Resolved, That engineering and technical societies be allowed desk room in the Club house for secretarial purposes, free of charge, upon application, which application shall be approved by the Board.

Mr. Snook was appointed a Committee of one to devise ways and means for increasing the membership of the Club.

ABSTRACT OF MINUTES C

STATED MEETING, APRIL ·

The meeting was called to order by Vice Presi and visitors in attendance. The minutes of the R and the Special Meeting of March 14th were appı

The Secretary announced that Colonel George min Smith Lyman had been unanimously elected

Mr. Edwin S. Jarrett presented a paper entit Woolworth Building."

Mr. G. F. Shaffer presented a paper entitled "The Difficulties Encountered in the Construction of the Woolworth Building"

The papers were discussed by Messrs. Manton E. Hibbs, W. C. Furber, D. Robert Yarnall, and Edwin S. Jarrett.

REGULAR MEETING, APRIL 18, 1914

The meeting was called to order by President Swaab with 103 members and visitors in attendance. The Secretary announced that the Board of Governors at their meeting, held Friday, April 17th, had elected to membership the following: Active, Harry Bortin, Fred W. Fernald, Frederic M. Gardiner; Associate, O. C. Gilbert, Wm. R. McLain.

The death of Alexander E. Harvey, Jr, active member, was also announced.

The papers of the evening were presented by Mr E. P. Roberts, of Cleveland, Ohio, and Mr. Charles G. Darrach, of Philadelphia, entitled, "Report on Public Service Properties," and "Valuation of Properties of Public Service Corporations," respectively, which were discussed by Messrs. Ledoux and Parker.

JOINT MEETING OF ENGINEERS' CLUB AND THE AMERICAN SOCIETY OF MARINE DRAFTSMEN, DELAWARE RIVER BRANCH, MAY 2, 1914

The meeting was called to order by President Swaab at 8:35 P. M. with 146 members and visitors in attendance

Mr W. A. Dobson, naval architect, Wm Cramp & Sons Ship and Engine Building Company, presented the paper of the evening, entitled, "The Evolution of the Modern Battleship," which was discussed by Messrs. Hess, Hentz, Parker, and S H. Wright. Mr. Elliott Snow, naval constructor, Philadelphia Navy Yard, and Mr. A. L Church, of Baldwin Locomotive Works, also spoke on the subject.

A unanimous vote of thanks was extended Mr. Dobson.

REGULAR MEETING, MAY 16, 1914

Secretary announced that the Board of Governors at their regular meeting held May 12, 1914, had elected Adam Cooper Warfel and Jordan Homer Stover to Junior Membership.

The names of Dr. Carl Hering, Richard Gilpin, R. G. Develin, Richard L. Humphrey, Thomas C. McBride, E. M. Evans, W. P. Dallett were submitted to the Club as having been elected by the Board of Governors to constitute the Committee on Nominations for the year, in accordance with Article V, Section 2, of the By-Laws. The list was ordered printed and brought before the Club at the June meeting, at which time it will be altered or accepted.

Joseph W. Richards, Professor of Metallurgical Engineering, Lehigh University, presented the paper of the evening entitled "Electrometallurgy," which was discussed by Messrs. Hering, Hess, H. M. Chance, Kenney, Thomas M. Chance, Maignen, Goodwin.

Mr. Hutchinson moved a vote of thanks which was amended by Mr. Hess, to include the commiseration of those present to those members who could not get to listen to Prof. Richards' splendid paper.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXI OCTOBER, 1914. No. 4

PAPER No. 1142

THE EVOLUTION OF THE BATTLESHIP OF THE DREADNAUGHT TYPE

By W. A. DOBSON

May 2, 1914

The ship of the line, built of wood, reached its greatest development just prior to the Civil War of the United States of America. The change from wood to iron covered a period of twenty (20) years, or from 1856 to 1876. A little later than the end of this period sail power was abandoned and steam relied upon entirely, the last full rigged ship of the United States Navy being the "Newark" as originally built. In wooden vessels the United States led the way among the nations, and its models and methods of construction were eagerly sought after and copied by foreign navies.

The "Hartford" and "Franklin" classes were of the best American type, and were immediately followed in the English Navy by similar vessels. The United States was rich in building materials, especially in live oak, from which the frames of the vessels were made, and which was practically indestructible. For this reason, perhaps, as well as that its corps of naval constructors were men of great practical skill in wooden ship building, the United States continued the use of wood when the lack of such material

was driving the European navies into the use of iron in place of wood.

A study of the construction of one of these fine specimens of naval construction is of great interest, especially when the construction was more or less composite. In the best vessels iron was used in strapping the frames both inside and out, and reinforcing the upper strength members, with iron clamps. The vessels were full rigged, having auxiliary machinery capable of steaming at 10-knots' speed. They were fitted with two-bladed propeller wheels, which were hoisted or triced up above the water line when the vessels were under sails.

The vessels were armed with smooth bore muzzle loading guns, generally of 8-inch diameter of bore, throwing solid shot of 68 pounds and having a penetration of about four inches in wrought iron at close range. Later in the United States Navy eleven-inch pivot guns were used, one being mounted on the centerline, usually forward, and served on either broadside.

The reason for the superiority of the United States designs for wooden vessels of this period is perhaps little understood at the present day. To fully appreciate it one must have intimate knowledge of the character and personality of the corps of constructors of the Navy at this time. For many years the design of vessels rested in a Board of Navy Commission, to which were attached a Chief Naval Constructor and a Chief Engineer. Later both Branches were detached from the active control of the Line and became separate Bureaus. At the head of the Construction Bureau stood Mr. John Lenthall, a man educated in the French technical schools of the time, which were certainly ahead of the world in mathematical investigation of the principles of applied mechanics, especially in the field of Naval Architecture. Mr. Lenthall was the peer of any naval architect of his time in technical ability and training, either at home or abroad, and to him alone must be given the credit for the strength of construction and harmoniousness of design that characterized the vessels of the United States Navy at this period. The remaining members of the corps under him were men of great practical skill in shipbuilding and of great natural ability, though perhaps with little knowledge of the application of mathematical principles to the art of shipbuilding.

With Mr. Lenthall to advise as to the disposition and combination of materials, for the use of iron was adopted for increasing the

strength of the members under greatest stress, and a score of men like William Hanscom, Mintonye, and the Harts to carry into execution his ideas, the United States had the finest wooden vessels afloat, by right of technical and practical skill, which we are little apt, in these days of more widely diffused knowledge, to be willing to accord to these giants of their day.

Unfortunately Mr. Lenthall did not believe in the Monitor type and refused to commit the Bureau to the advocacy of their construction. The "Monitor ring" was strong both in politics and in the Gustavus Fox wing of the Navy Administration, consequently the design and construction of the Monitors prior to 1875 were taken out of the hands of the Bureau of Construction and Repair and placed in the hands of the Engineers of the Navy, with Mr. Stimers at their head. The result of the study and design of the Engineer Board was the class of Monitors known as the light draft Monitors which owing to miscalculation would not float and proved a complete failure. As a "cub" in the Roach shipyard, I was much interested in seeing several of these broken up and noting the skill displayed in their construction. After this fiasco the design of the Monitors "Puritan" and "Miantonomoh" class were placed in the Bureau of Construction and Repair under Mr. Isaiah Hanscom, who succeeded Mr. Lenthall as Chief of Bureau.

The scarcity of building material led to the building of iron vessels in the English and French Navies. The idea of an armored vessel seems to have occurred to both these nations at about the outbreak of the Civil War with us and the result was the "Warrior" in England and the "La Gloire" in the French Navy. The belt of armor on each vessel was made four inches in thickness, which was sufficient to repel the 8-inch smooth bores of the day at fighting range. It should be borne in mind that vessels carried as many as fifty of the 8-inch 68-pounders arranged in broadside with bow and stern chasers. While this development was going on abroad some of the brightest minds, quickened by the possibility of war in the United States, were giving earnest thought and study to a fighting machine, notably John Stevens and Theodore Timby, American born citizens, and John Ericsson, a Swede, who afterwards became an American citizen. Stevens made the plans of a remarkable vessel called the Stevens Battery and at his death left a sufficient sum of money available for the completion of the

vessel. The vessel, however, was never completed, but some of the features of her design will be referred to later on. Theodore Timby had given years to the perfection of a revolving fort or turret of steel, in which was housed a number of guns. This fort he mounted on a raft which was intended for harbor defense. I have talked with Mr. Timby, and have gone over with him the original plans made in the '50's, and am glad to bear testimony to the originality of his design. It remained, however, for the genius of Mr. Ericsson to combine the ideas of both Timby and Stevens in the epoch making vessel known as the "Monitor." I fully believe Mr. Ericsson was working along entirely independent lines from either of these gentlemen, but all three had many ideas in common, and the fact remains that Mr. Timby was so protected by patents of his design that Mr. Ericsson had to pay $5000 royalty on each of the turrets fitted on the Monitor class.

Just here we will refer to the Stevens battery, which has a lasting influence upon subsequent warship design. Its building period extended over such a term of years, from 1860 to 1870, that many of its original features were modified entirely and the experience of the naval combats of the Civil War incorporated. However, Mr. Stevens started out to build an armored vessel with guns of one calibre carried in revolving turrets. In this general conception he and Ericsson were on common ground, but Stevens went much further. He introduced the armored deck with sloping sides extending down to the lower edge of the armor belt, precisely what was known as the protective deck of later years. His main belt extended from stem to stern. The vessel was fitted with twin screws, and the same type of balanced rudder now fitted to nearly all United States battleships found its prototype in this wonderful vessel.

Unfortunately the vessel passed into the ownership of the State of New Jersey and was never fully completed. Attention, however, is called to the features incorporated and actually built which afterward became fundamental in battleship design:

1. Battery of one-calibre guns mounted in turrets.
2. Twin screws.
3. Protective deck.
4. Balanced rudders fitted in the deadwood or run of the vessel.

While these features were being dreamed upon and slowly put into execution, Mr. Ericsson, for the Northern States, and the designer

of the reconstructed "Merrimac" were pushing ahead and forcing upon their governments types of vessels that were to revolutionize the design of war vessels the world over, and which were known as the "Monitor" and "Merrimac." In the former was the complete waterline belt and armored deck with guns mounted in turrets, while in the "Merrimac" was found the armored casemate with sloping sides and the ram. The combination of these features has been perpetuated in battleship design to the present day.

The United States Government was so exhausted financially by the long war that it had neither means nor inclination to carry into effect the many lessons of the war, but England, ever watchful, profited to the utmost by the experience gained in our naval engagements and embodied them in the navy of iron vessels she was rapidly building.

About this time there arose in England a group of notable men who by practical and technical training were well able to establish and apply the valuable lessons of the American Civil War. These were Scott Russell, Brunel, Sir Edwin Reed, and Rankine, followed by William John, William White, Nathaniel Barnaby, Francis Elgar, and Martel, while in France such men as DeBusy and Bertin were investigating and working along the same line.

To Russell must be accorded the credit of starting scientific inquiry into the lines of the least resistance, to Brunel the best disposition of material to meet longitudinal stresses, and to Reed and his young assistants the cellular construction and framing which did so much to obtain the necessary strength with less weight.

The designs evolved ran the gamut of the armored broadside with multiple guns of the "Warrior" type to the battery of few guns of larger calibre mounted in turrets, such as the "Devastation" type of high freeboard Monitors. These designs finally worked into the mixed gun battery with the large guns mounted in turrets or barbettes and the smaller guns in armored casemates. This type of battery prevailed in one form or the other, up to the time of the Russo-Japanese War. The fight through that long period was between armor and guns, with varying results. At one time the armor would defeat the guns, then the guns would penetrate the best armor made. The same fight is still on, with honors resting with the guns. Then began the long fought question between speed and protection and armament, or the feature of offense and defense.

The lesson hastily drawn from the fight in the Japan Sea was the all gun battery of heavy guns, with a numerous secondary battery of very small guns. Calm and cooler consideration, however, has given the larger calibre rapid firing gun its old place as a defense against torpedo craft, with the exception perhaps that protection for this class of gun has been dropped. The cycle has been made and we are again with batteries of mixed calibres just as at the close of the Civil War, only with all the tremendous increase in power and rapidity of fire.

At the time of the Spanish-American War our battleships had as their primary batteries 13-inch or 12-inch guns, combined with 8-inch, all in turrets, the heavier guns being mounted on the centre-line forward and aft, and the 8-inch on either beam. The secondary battery ranged from 6-inch down to 3-pounder rapid fire guns. The chief lessons taught by this war, insofar as battleships are concerned, were the value of keeping a navy in the pink of condition, both men and material; the necessity of radical changes in our own target practice; and the necessity of adopting smokeless powder. The gallant effort of Cervera's fleet, without proper stores or good ammunition, and its pathetic destruction, as compared with the famous trip of the "Oregon," speaks volumes for the necessity of a high standard of naval efficiency and drill. The remarkably low number of hits for the number of shots fired was a surprise to our naval authorities and brought about such a radical reform in target practice, mounting of guns, and service of ammunition, that today our vessels are excelled by none in the number of target hits.

For the purpose of our discussion, the features of the modern "Dreadnaught" may be considered under two heads: viz., Offense and Defense.

There is a certain amount of displacement at the disposal of the designer, for the sum of all the weights must equal the displacement at a given line of flotation. Therefore, no one feature can be abnormally emphasized except at the expense of some other; for instance, to carry a great number of heavy guns and ammunition means thinning down the protection in shape of armor. The vessel may be strong in offense but correspondingly weak in defense. The speed may be made extremely high, and combined with heavy armament will produce a vessel that can deliver a blow and run, but she cannot take punishment, for she must lack commensurate

protection. It seems, therefore, that the wiser policy is one of good speed and equally balanced armament and protection. These are the general features followed for American Dreadnaughts. The amount of weight devoted to the comfort and health of the ship's complement can well be considered as belonging equally to offense and defense, for the sound mind and the sound body are pre-eminently necessary for the successful issue of the battle.

The features of offense may be grouped under three heads: 1st, the battery of primary or heavy guns; 2d, the torpedo battery; and 3d, speed, when considered as a means of overtaking an enemy and choosing the weather gauge at the time of engaging.

The features of defense may likewise be grouped under three heads: 1st, armored protection; 2d, the auxiliary battery, as a means of repelling torpedo boat attack; and 3d, speed, as a means of refusing an engagement only.

The two divisions are so closely interwoven as to make it hard to consider them apart except in general terms. We may, therefore, take up the features in a general way and afterwards combine them.

First comes the main feature of offense, i. e., the primary battery. Almost all nations have come to the one-gun battery for its chief weapon of offense. These guns range from twelve inches to fourteen inches in diameter of bore, with the prospect of going as high as fifteen inches. The weight of armor piercing shell and the bursting charge vary in general terms as the cube of the diameter of the bore of the gun. It will be seen, therefore, that the impact from a 15-inch shell is practically double that from a 12-inch shell.

The emplacement of the heavy guns, therefore, is one of the first importance, for the gun must be so placed as to command the greatest arc of fire at such a distance from the water as to be fought in moderately heavy weather, and so placed that its protection by heavy armor is feasible. This opens the question as to whether head and stern fire or broadside is the more valuable. Some designers sacrifice weight for the supposed advantage of head and stern fire. In coming up with and engaging an enemy no doubt head and stern fire will be valuable in the hope of getting in a crippling shot at very long range, but when the vessels are within good fighting distance it is most natural to suppose that the pursued will sheer enough to bring the greater number of guns, or her broadside, to bear on the pursuer, who will also adopt like tactics so that the fight will continue, the vessels circling in parallel lines.

In fleet action the use of the battery in broadside is the one giving the greatest delivery of metal. It, therefore, seems that the greater advantage is to be gained from a moderate degree of head and stern fire combined with the heaviest possible broadside fire. To obtain this with the least weight of protection we are irresistibly led to placing the guns on the centre line so that they may fire on either broadside. To have the advantage of this system and at the same time obtain good head and stern fire the United States designers were forced to place the second set of turret guns from the forward and after ends, so that they could fire over the guns in front of them. This emplacement was brought out in the "South Carolina" class and strongly criticised at first, especially by England, who feared the effect of the blast from the upper guns upon the crew of the lower turret. Exhaustive experiments in this line have proven that the fear is groundless, with the result that this emplacement has become the standard of all nations.

In the early American Dreadnaughts the heavy guns were mounted in pairs in turrets, using the standard American emplacement. This arrangement gave at the best four guns ahead and astern, with the broadside varying in accordance with the number of turrets mounted. This has given place to mounting three, and in the French Navy even four, heavy guns in a single turret. With a battery of ten or twelve heavy guns the emplacement may be made in four turrets, the forward guns and their ammunition being entirely clear of and forward of the machinery, while the after guns and ammunition abaft the machinery. This is a most desirable arrangement, as it lends itself to the better ventilation of magazines and prevents interruption between engine and fire rooms. In one case we may have three guns each in the lower turrets and two each in the upper firing over the turrets below. This would give five heavy guns ahead and astern and ten on either side. By using three guns in each turret the head and stern fire may be increased to six guns and the broadside to twelve. The French in their latest design have placed four guns in one turret. With twelve guns, if mounted in four turrets, this would mean no increase in head fire over the 3-gun turret, but renders it possible to mount all twelve guns in three turrets, with the second turret firing over the first, giving eight guns ahead, twelve on broadside, and four astern. All sorts of variants may be made by using the

several types of turrets here spoken of. Personally, I do not believe the four-gun turret will prove successful. The outboard pair of guns must be placed so far from the center that in firing a single pair the whip must be enormous. Of course, in firing in salvo this objection is not a serious one. However, the number of guns per turret may vary. The mounting of all heavy guns in turrets protected by armor and placing these upon the centre line has been universally adopted and the United States must be given the credit for originating this plan, embodying the greatest efficiency with the least weight.

The next feature of offense is the torpedo battery. The use of torpedoes on battleships is almost universally confined to submerged tubes. As these are placed generally in broadside below the waterline they are from their location well protected. There seems to be little actual experience from which we may measure the value of this arm of offense. The range has been greatly increased, and from the fact of their power to damage a vessel so much greater than the gun they must have serious consideration. They are used at comparatively close range and, therefore, must necessarily be the weapon to aid in giving the finishing touch to the conflict. A vessel may be fought after she has been hit by many projectiles from the main battery, but she cannot survive many hits from modern torpedoes.

These weapons deliver their blows below the armor belt and at the most vulnerable part of the ship, so that one explosion from a successful delivery may seriously cripple the battleship, and more than one may put the ship out of action. The old "Maine" in Havana harbor is an example of the destructive effect of an underwater explosion.

Speed is next to be considered as a means of offense. It can well be conceived that under certain circumstances speed is a most valuable adjunct to the offensive power of a battleship. It means arriving speedily at the scene of action, the overtaking of an enemy, and the choice of the weather gauge, all valuable assets for the battleship, but where we emphasize speed in excess of 21 knots at the expense of the armament and protection of the vessel we are departing from the true battleship. It is possible to conceive a cruising battleship with such heavy guns lightly protected, and such tremendous speed that she can keep out of range of the slower vessel with more protection and less calibre of guns, and deliver

her blows with impunity. This may look well on paper, but it is entirely possible to arm the slower vessel with the largest calibre guns. Then the usefulness of the swifter but lightly protected vessel as a first class battleship ceases. I fully believe the United States is right in adopting a speed of about 21 knots and putting the difference of weight into protection. It seems to me to be a fallacy that the most efficient protection that can be given to a ship is the protection furnished by its own powers of offense. This has been ably argued by some of the leading experts, especially in England, but the answer seems to be found in a fewer number of equal calibre guns, but so well protected as to be able to reply with full vigor to the first onslaught of the vessel with a greater number of guns with little or no protection. It is the expectation of artillery experts that with the present accuracy of gun fire and firing "in salvo," an engagement between battleships will be settled in less than ten minutes. The staying power then is to be found in armored protection to the primary battery and vital parts of the vessel. If this theory is well founded, the engagement will be over before a ship's torpedoes can be brought into action, and the value of torpedo craft during an action of such short duration very much lessened.

This brings us to the features of defense. It is obvious that to have a perfect fighting machine we must be able to protect our motive power, our ammunition and supply of same, our guns, and the stability of the vessel. In other words, the armored portions must be sufficient in area and thickness to have our vessel a floating fort capable of fighting its guns and of being maneuvered at will, even after the habitable portion has been swept away or laid open to the sea by gun fire. This means a careful consideration of the moment of inertia of the plane of flotation included within the armored area, and which may be considered as remaining intact after the most severe fighting.

Taking then a four-turret battleship carrying ten to twelve 15-inch guns as its primary battery, and having sufficient power to give a speed of 21 knots, it would seem that the main armor belt should extend to and include the foremost and aftermost barbettes protecting our turret gear and ammunition supply, and should be at least fifteen feet in depth. Forward and abaft these points the armor should extend to the bow and stern in the form of a waterline belt. At the top of the main belt should be worked the main

protective deck carried flat across the vessel; below, at a height of about three feet above the load line, should be worked a splinter deck turning down at the sides to meet the armor shelf. The slopes of this deck should be of considerable thickness to take care of shell fragments.

It may be of interest to dwell for a few moments on the development and application of the turtle back or protective deck to war vessels. As mentioned earlier in the paper, the Stevens Battery incorporated this feature, but before this a lieutenant in the U. S. Navy, by the name of Hunter, invented an armored deck with the sides sloping down at the sides of the vessel below the waterline. In the development of foreign war vessels this system was adopted for the protection of the magazines and machinery of protected cruisers and in some cases sole reliance for protection to the vital portion of the vessel was placed in decks of this sort for ships of large displacement and heavy artillery. Later on, this principle was applied to battleships, the idea being that if the projectile penetrated the belt armor the armored deck would stop the fragments of shell or deflect the solid shot.

The accepted method of the present day is to work a flat deck of armor at the top of the main deck and a sloping deck not more than one and one-half inches thick on the slopes as a splinter deck.

It has been proposed to work the main belt in two thicknesses having a space between filled with wood, the outer thickness to be two or three inches and the remainder of belt in one thickness; the object is for the outer belt to receive the first shock of capped shell and the second or main thickness to deflect the shell which would be decapped by the outer armor. The barbettes and conning towers would begin at the main armored deck and be carried as high as the design would require. We would then have an armored raft with forts formed by the turrets and barbettes, the armor absolutely protecting machinery, magazines, ammunition supply, steering gear, guns, commander's position and means of interior communication, and the stability of the vessel. The rest of the vessel could be shot away and yet the fighting machine be intact. We are, however, still in danger from torpedo attack. To guard against this, internal armor is fitted abreast magazines and machinery corresponding about to the limits forward aft of the deep belt of external armor, extending from the inner bottom to the splinter deck. The space between the armor and the outside

plating (which should be as great as practicable) is divided in cellular compartments. From attack by torpedo boats our defense lies in the auxiliary battery of rapid fire guns of sufficient size to sink the small craft. These gun positions should be unarmored, that is, not protected by armor, for armor commensurate with the size of guns would be smashed into fragments by the heavy guns of the enemy's primary battery and become a distinct source of danger from the mitraille. It therefore seems useless to expend good displacement in this manner. If the theory of the artillerists is a sound one, that the battle will be over in less than ten minutes, torpedo boat attack during an engagement is impracticable and should be made preceding a battle. If, however, as many hold, the battle is to occupy considerable time, it would appear that the psychological moment for torpedo boat attack would be after the battle had been under way for some time and the auxiliary battery put out of commission. Speed as a means of defense seems to be solely in the ability of the vessel to keep out of danger by refusing to engage, but this would be against all traditions and avoiding the very purpose of the battleship.

The location of magazines at their best is forward and abaft the machinery spaces. There the magazines can more readily be kept cool and the stowage of ammunition not interfere with the arrangement of the boiler and engines. The powder used, nitrocellulose, in our guns deteriorates very rapidly when heated above 90° F. It therefore becomes necessary to ensure the stability of the powder and to prevent the generation of dangerous gases caused by the decomposition of the powder by means of cooling the magazines artificially and so keeping the temperature down to a point of safety. To accomplish this the magazines are lined on the inside with compressed sheet cork varying from two to four inches in thickness. This is cemented directly to the steel plating, frames, and beams of the steel structure. After the cork is in place the seams and joints are smoothed up with plastic cement and then the whole surface coated with plastic cement until a smooth surface is obtained. This surface is in turn painted with gloss paint, the object being to obtain a polished surface which will be slow in radiating heat. The rougher the surface the greater the radiation of heat, for each points acts as a radiating fin. The smooth gloss paint gives as near as may be a uniform surface with slow radiation. The magazine having been insulated in this manner, a series of

supply and exhaust ducts are fitted, reaching to all parts of the magazine. The air drawn in the first place from the atmosphere is forced through an air cooler and moisture separator. By closing the intake from the atmosphere the air is circulated to the magazines and back through the cooler until the desired temperature is reached. The admission of air to the magazines is controlled by thermostats and dampers, which enable us to keep a uniform temperature in the magazines.

The present day battleship resembles a miniature city in its provision for the safety and health and comfort of its officers and crew, to which must be added all the apparatus for sending this mass through the water at a speed of 21 knots, or nearly 25 miles, an hour, and handling the vast engines of destruction lying latent in its magazines and enormous guns.

Let us look at these. First, we must have light throughout the vessel, so an electric plant for lighting must be provided and wiring to conduct the current to all parts of the vessel. Drinking water must be provided, so an evaporating plant is fitted to enable the salt water to be turned into good potable water. This is conducted to the various bath rooms, lavatories, and drinking scuttles throughout the vessel.

Heat must be provided and means arranged whereby fresh air, heated by steam, is forced into and through the living quarters.

The turrets and guns must be so mounted that each set may be trained at will, or elevated and depressed, as one man may elect. Reliable apparatus for this purpose must be provided. The ammunition must be brought from the magazines down below the waterline to the breeches of the great guns in the turrets some fifty feet above; each shell may weigh three-quarters of a ton and must be brought precisely to the loading position at the rear of the gun. Then a rammer must reach forth its long jack-knife like arm and push the shell and then the powder home in the chamber of the gun. This must be done in any position of the gun, so that electric mechanism reliable and flexible to a degree must be provided.

The vessel must have apparatus for mooring and docking, so winches driven by electricity supply this want.

Outside of a navy yard, when a war vessel is in commission, she is rarely tied up at a dock, so that small motor and rowboats are a necessity for communication with the shore. These boats must be stowed out of the blast of the guns, for, although in a

battle the boats are lowered and moored in the open sea, yet in peace time the boats must be so stowed that the guns can be fired at target practice without tearing them to pieces by the blast. This necessitates nesting them and handling them by cranes or derricks operated by electric winches.

A gear for the rapid coaling of the battleship must also be installed, which finds its best motive power in electricity. The most modern, approved type of steering the vessel is by mechanism actuated by electricity, for this action is positive and reliable, and such an apparatus eliminates steam pipes with their heat and leaks in the living quarters and storerooms.

In addition, the ice machinery, laundry equipment, galley, and baking apparatus are operated by electric motors, so that the battleship must be provided with no inconsiderable electric power plant.

As referred to earlier, the magazines must be artificially cooled, the perishable stores for the food supply of some 1200 men must be kept in cold storage, and ice for ship's use must be made. To accomplish this an ice plant is provided. Up to the present time the type of ice machine used is the "dense air," in which the air is alternatively compressed and cooled, then expanded.

A sewerage system must also be arranged for, as we have on a Dreadnaught as many people as are found in many villages of the first class. Consequently, drains from baths, toilets, washrooms, galleys, and decks all have to be provided.

The battleship is no exception to the general dictum that "bread is the staff of life." Therefore, means for supplying some 1200 men with good bread are ample and thorough. Bakeries are fitted, provided with power operated dough mixers, and with dough testing apparatus. In addition, all utensils for cake and pastry baking are provided.

Next comes the laundry, for the clothes of the sailors are washed and ironed by machinery; so all the appliances, both steam and electric, found in a first-class laundry have their counterpart on a battleship.

Then the sick must be cared for, ordinary cases of illness separated from contagious diseases and from those where the knife is the sole resort. We have then the ordinary hospital or sick bay with its contagious ward, and an operating room furnished with all the antiseptic appliances and instruments which make successful operations of the most serious character.

Next comes attention to the moral and spiritual side of the natures of the men. It is human to err, and the crew of a Dreadnaught are intensely human; hence, a jail on shipboard with several cells, where a diet of bread and water tends to good resolutions. But all men are not bad and bad men are not always in trouble, so there is a chaplain on board who at stated periods conducts divine service and to this end must be provided with a pulpit, and this makes the church.

So each battleship is a fortified city, carrying within its armored walls all the activities of the ordinary citizen, but always with the refining and civilizing influence of women absent, and we have nearly all the ordinary municipal plants in operation, for we have light, heat, water, drainage, power, hospitals, church, and laundry plants quite as in a well ordered city.

In the evolution of the battleship, one element of doubt pertaining to its design has been removed, and can now be determined before hand with absolute and scientific accuracy. I refer to the powering of the vessel.

In the days when fourteen knots was considered a high speed the power necessary to drive the vessel at a speed not exceeding fourteen knots was ascertained largely by the use of Rankine's formula, which took into account the wetted surface of the vessel, the entering angles of the vessel's form and the water set in motion by the passage of the vessel through the water, or what he termed augmented surface.

When higher speeds came more and more into vogue it was seen with regret that Rankine's formula had its limitations and something more reliable than an "educated guess" must be substituted. About this time Mr. Froude began his resistance investigations on behalf of the English Admiralty, which became world famous and led to the promulgation of the method of comparison known as Froude's Law of Comparisons. This was a great boon to the designer, where it was impossible to have the resistance of the model ascertained by tank experiments, provided that one had a sufficient stock of trial data for vessels somewhat similar in form. This was the method used by the Navy Department prior to the installation of the model basin apparatus at the Washington Navy Yard, under the auspices of the Bureau of Construction and Repair. In those days it was customary for the Bureau of Steam Engineering and the Bureau of Construction and Repair to prepare independent

curves showing the power required at various speeds and then compare them. A reasonable margin was added to the power for safety's sake, and then in designing the machinery a little margin was allowed to be sure that the prescribed power would be obtained. From this it can be seen that it was not so difficult a matter to obtain a very considerable premium for speed in excess of the contract requirements, when such bonuses were allowed. With the coming of more exact methods, instituted by that very able constructor of the United States Navy, Mr. David W. Taylor, the bonus system was swept away and the contract made for a definite speed; anything obtained above it was simply glory for the contractor.

Ascertaining the resistance of the model for a certain range of speeds not only causes one to await quietly, without undue loss of sleep, the outcome of the speed trials, but makes it easier to place the cause of the trouble, if any is experiences, where it properly belongs.

In the old days, when the vessel failed to realize her expected speed the engineer at once laid full blame upon the form of the hull, a trick not yet entirely forgotten by our brothers on the engineering side of the fence. Now that the hull resistance can be definitely foretold, and the engines found to be capable of developing the required power, inquiry turns at once to the design of the propeller wheel as the unknown factor, and one where experiment may give beneficial results. In other words, it narrows investigation down to one element instead of any one of three. There is still further benefit to be derived from model tank results in warship design, where every ton of displacement is of great value. In general terms, increase in power means increase of weight, and when a generous allowance has been made to insure the necessary power being obtained it must be at the expense of weight; in other words, some other department of the vessel is being robbed of its proper share of the given displacement in order that we may be sure of our speed. The model tank prevents this by showing us the necessary effective horsepower at the very start of the design. This also follows into the radius of action for a vessel. The necessary fuel for a given radius may be accurately ascertained and unnecessary weight saved to go into armament or protection. The design and development of Dreadnaught battleships present as many features of interest today as war. The gun is

undefeated by armor, and the submarine has had no adequate reply made to the possibilities of its attack. A feature that must be given serious consideration is protection against an attack from the sky. This may well take some form of turtle back in connection with the upper level of protective deck plating.

DISCUSSION

CHAIRMAN.—This paper is so able that there is, I suppose, nothing left for discussion, but there may be some questions that somebody will want to ask Mr. Dobson, and probably he will be willing to answer them.

MR. HENRY HESS.—I remember a number of years ago, when I was connected with the Ordnance Department of the Army, we were much interested in the accuracy of gun fire, and the only experience we had at that time with relatively recent ordnance was somewhere down in South American waters, where I believe the various battleships had records of rather marvelous accuracy, but nothing like 99.9% pure as we have today. I believe the observed accuracy on those vessels was something under 2% when the other fellow was shooting back; it may possibly have been 3%. They claim an efficiency today, for shooting at a target, of, I believe, somewhere around 90%, and some say 100. It would be interesting to know what the accuracy of fire is going to be when the other fellow shoots back.

MR. SNOW.—Permit me to say that this is a very splendid paper from Mr. Dobson on the Evolution of the Battleship and Warship Design, and the more I think of it the more I have forced upon me the truth of the expression used by Mr. George W. Dickey of the Union Iron Works, San Francisco, that "the modern battleship is a complicated combination of compromises."

The paper being to some extent historical, may I be allowed, to add one item that is now somewhat historical, but nevertheless an important question even at the present time? I allude to the use of cofferdams. These were first seen in the French Navy, and were first used on the Cruiser "Sfax." At the time we students were in Paris, we received a request for information as to the kind and character of material used to pack the cofferdams. Curiously enough, about the same time that we got this request there appeared in the Paris edition of the New York Herald a reference to the same subject, on the effect of cofferdams on ships, and also, by a curious coincidence, on that same day a French Officer, high in authority, made a social call on us youngsters. We promptly turned the conversation toward the question of cofferdams and got the information that we wanted, namely that "coco" cellulose was being used as a packing material.

MR. A. L. CHURCH.—The question of the weight that goes into a battleship is a vital one, and it may be interesting to some of you to know that an Admiral when he is put aboard ship weighs about 75 tons; you have to provide for the Admiral, the band, his crew, and sometimes an extra aide, etc.

Another question deals with the accuracy of fire, and particularly on going around to a point of range at top speed, and this is the danger zone in firing, with our modern twelve-inch and fourteen-inch guns and large projectiles; the

to shoot over the banks of the river where the boats were lying. In this way the military masts of these vessels originated.

MR. J. C. TRAUTWINE, JR.—I wish I were in position to discuss Mr. Dobson's paper.

Unfortunately I am handicapped, not only by dense ignorance of his subject, but by some maladjustment of my mental equipment, which forbids my taking the battleship seriously.

The battleship recalls the ancient story of the Chinaman whose house burned down, incidentally roasting the family pig, and who was thus led to the di[illegible]

of the attractions of roast pig as an article of diet. The discovery led to the general burning of houses in China, for the sake of enjoying roast pig.

Presumably, the Chinese government organized a Department of Pig-roasting; private Chinese corporations devoted themselves, in all solemnity, to the skillful construction of houses adapted to the purpose; these houses may have been christened (or Confucianized) with bottles of the Chinese equivalent of champagne; and their engineers doubtless read papers upon the then modern developments in the design of such houses.

Now, my trouble is that, if I had lived then and there, I could not have resisted the temptation to wonder why my compatriots failed to see, close at hand and obvious to all, a vastly less inefficient method of procuring roast pig.

Similarly, today and here, each nation seeks its own interests, and yet each nation goes about serving its interest by means which can lead only to losses compared to which those of the house-burning Chinamen are insignificant.

And I am so constructed that, in spite of my interest in the technical features of Mr. Dobson's paper, this interest is overshadowed by the wonder that modern nations, presumably enlightened and therefore awake to their real interests, should (even in obedience to the traditions of antiquity) go on in a line of activity inevitably ruinous to those interests, while their own experience shows the overwhelming superiority of rational methods.

But these preposterous activities are still with us; and whatever is to be done should be done well. Mr. Dobson has admirably shown how our national folly is carried on today, and the Club is indebted to him for his masterly handling of the subject. I therefore move a vote of thanks to Mr. Dobson for his highly interesting (and, if possible, still more highly suggestive) paper.

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2. Fused Salts: (Electrolytic Furnaces).
   A. Simple Salts: Na, Ca, Mg, Ce, Zn.
   B. Solutions in fused baths: Al.

II. Electro-thermal Methods (Electric furnaces).
   1. Fusion of metals or alloys: Steel, Brass, Bronze, Aluminium.
   2. Reduction of compounds to Metals or Alloys: B, Si, Mn, Zn, Ferro-Alloys, Pig Iron, Pig Steel.

Electric current can be utilized for electrolytically decomposing chemical compounds. The electro-thermal method is that in which the current is used for its heating power only, and in which some other agent does the decomposing. These two are very distinct from each other, and I will spend a few minutes in emphasizing the difference between them.

In the electrolytic method you depend upon the electrolytic decomposing power of the current. You necessarily have to use a direct current except where the electric cell itself rectifies the current, which is very exceptional. In all practical electrolytic operations, only direct current is used.

In electro-thermal work, where the current is used for its heating power only, direct current or alternating current may be used. Alternating current is cheaper and does not give the indirect effects that a direct current will give, for with direct current in an electric furnace you usually have undesired one-sided effects at the electrodes.

In the electrolytic furnace the amount of useful work done, as measured by the amount of the product, is proportional to the amperes of the current which pass, according to the laws discovered by Faraday. When you are passing a current through an electrolytic cell, the amount of product is independent of the volts which may be expended on the cell, and is dependent only upon the amperes. It is only secondarily that the volts used affect the amount of product which can be obtained by forcing through more amperes. It is easy to calculate the theoretical amount which you should get at 100 per cent. ampere efficiency upon the amperes flowing through any electrolytic cell.

In electro-thermal work the heat energy of the current is that which is utilized, and the heat effect is proportional to the amperes multiplied by the volts, so that the product will be proportional

to and determined by the amount of energy which is expended upon the furnace as measured by the K. W. H. meter. The two processes are thus seen to be essentially distinct in these two fundamental ways. A third distinction may also be drawn between them: that in the electrolytic apparatus you must have an anode and a cathode arranged for proper electrolysis, and proper arrangements for the escape of the gaseous products at the anode and the collecting of the products at the cathode. In the electro-thermal methods you have no such distinction of parts. There may be electrodes, or the terminals or poles, but they are not positive and negative, they are not anode and cathode, and there is no arrangement of the cell which copies or duplicates the electrolytic arrangement which is necessarily part of an electrolytic operation.

I will discuss now why the electrolysis of fused salts is sometimes classed erroneously under the electric furnace methods. Fused salts generally conduct current freely. Their order of resistivity is that of a well-conducting aqueous solution like the best conducting sulphuric acid, something like one to three ohms per centimeter cube. When you pass the current through and decompose fused salts, the operation is primarily electrolytic—the decomposition of affused salt to obtain its ingredients. However, you cannot pass an electric current through any solution or, in fact, through any material without generating some heat by the passage of the current. If you electrolyze with an intense current you generate much heat, and you may reach a point where the internal heat generated by the passage of the current is so large as to keep the electrolyte melted without the assistance of the external heat with which you started the operation. By running the operation with an intense current, it is possible to get the salt melted and keep it so without the aid of electrolysis, thus incidentally generating enough heat to keep the salt liquid at the temperature at which you run, 300, 400, or 1000° Centigrade, such as when producing aluminum, etc. And by regulating the current you can keep the temperature just at the desired point. Many writers have been muddled on this point, and have thought that when outside heat is dispensed with you then have a furnace, and they have classed these with electric furnace processes. That is taking them away from where they properly belong. The fact that the operation is essentially electrolytic is not affected by the fact that the heat generated partly suffices to keep the bath melted, and whether

the heat generated keeps the bath melted or whether you have even to cool it down, that does not affect the classification; it is not an electric furnace process. I would ask you, when you read about electrometallurgical processes, that you will bear that in mind that the electrolysis of fused salt, when the current supply is sufficient to keep it fused, is necessarily an electrolytic operation. Some people think that when you are conducting an operation requiring a higher temperature than the ordinary one, you necessarily have an electric furnace. This difficulty has been solved by using the term "electrolytic furnace" for an operation of this kind, where the electric current performs electrolysis and also supplies all the heat necessary to keep the salt melted.

Taking up now the different methods of electrometallurgy, starting with the use of aqueous solutions among the electrolytic methods, when the only source of electric current was the battery, the plating of silver, brass, etc., and other metals, by means of an aqueous solution and electric current, was the only branch developed. The Elkington Brothers in England were the best-known platers of gold, silver, and other metals, using aqueous solutions to do electroplating. According to my definition, electroplating with pure metal used as an anode would not be included in electrometallurgy, and I should say at the present time, that electroplating with a pure metallic anode is not an electrometallurgical operation in the strict sense. I mention this because in the early days, when the battery only was used as a source of current, electroplating was called electrometallurgy. In Mr. Shaw's first book, he assumes that electrometallurgy means nothing more than the plating of the metals, the duplicating of medals and coins, starting with a pure metal as anode, and simply changing its form and plating it over. From the old books up to the present you will find much in them about electroplating or, in general, galvanoplastics, the art of changing the form of a metal. Elkington Brothers, who were plating gold and silver, were the first to utilize this principle for refining copper, away back about 1865. When the first dynamo was invented—the first machine of Wilde—there arose the possibility of using impure copper as an anode and plating out pure copper, thus saving all the gold and silver contained in the impure copper. That was the first process by which it was possible to extract gold and silver from the metallic copper when they were present in very small amounts, and the process owed its commercial

success to treating cheap impure copper, saving the gold and silver, and at the same time obtaining a very pure copper at the cathode. This is a real electrometallurgical operation. It has a few fundamental principles which I will set forth as concisely as I can.

To electrolytically refine impure metal, you must choose as electrolyte a soluble salt in solution, such that the actual metal you desire to get will go into the solution, and then you must use a depositing current of such quality and quantity that you deposit only the desired metal out of solution. When you take impure copper as anode and thus electrolyze it, there remain undissolved, at the anode, the gold, the silver, the platinum, little specks of slag and matte, and particles of copper, which drop to the bottom. This anode mud will frequently be 50 per cent. copper and 30 or 40 per cent. silver and gold. The iron, nickel, zinc, cobalt, tin, and a number of other metals have gone into the solution. The current density at the cathode must be high enough to deposit the copper but low enough to let the impurities accumulate in the solution, whence they have to be removed by other means. Those principles are the foundation of the entire copper refining industry, by means of which about 900,000,000 pounds of copper per year are refined for use in this country, the value running over one hundred millions of dollars. Similar principles are used for refining lead. For instance, Dr. Keith, of Philadelphia, worked out a very satisfactory laboratory process for refining lead many years ago. It was not satisfactory commercially, however; but in later years the problem has been solved by Mr. Anson G. Betts, and there are two or three such plants in operation in this country and abroad giving us a lead of very high purity, free from silver and gold, and particularly free from bismuth, which is one of the most difficult elements to get out of lead by ordinary refining processes. Bismuth remains behind in the slimes in such shape that it can be purified, and this process has increased very greatly the output of bismuth in this country. The lead is so free from bismuth that it commands a high price, being particularly desirable in the manufacture of white lead, for a trace of bismuth in white lead spoils its color.

Another element which is being electrolytically refined is zinc, which is more difficult to refine than copper or lead. There is also less margin commercially than there is for refining copper, and there is no gold or silver in it whose saving pays for part of the operation, so the refining of it is not as profitable as that of copper.

The electrolytic refining of silver was first made practicable by Moebius. Taking as anode the silver bullion which comes from the cupellation furnace, the silver, copper, and iron go into solution, while the gold and platinum remaining are not dissolved; by properly regulating the depositing current, only pure silver is deposited. Silver of the greatest commercial purity is made in this way.

Gold is electrolytically refined on the same general principles, but with differences in detail, by the Wohlwill process. The process was worked out at the Deutsche Gold und Silber scheide Anstalt in Hamburg. A solution of chloride of gold, electrolyzed with a sheet of gold as anode, gives off chlorine into the air, and the anode is not dissolved. If you add hydrochloric acid to that solution, making a strongly acid solution, there comes a point where the escape of chlorine gets less and less, until its escape is prevented altogether and the gold anode dissolves perfectly. That process was first put into operation in America at our Philadelphia Mint; I believe the electrolytic plant has since been moved to the assay office in New York. The gold, platinum, and copper go into solution, while the silver forms chloride and remains undissolved. By using a proper depositing current, pure gold is obtained. The gold beaters say they are getting much better results now from this commercial gold, because it is better than they were able to procure before by the acid chemical processes. The platinum is recovered from solution by a simple chemical operation, so that the platinum that used to stay with the gold and be lost is now saved.

Besides tin, lead, silver, copper, and gold, I believe there are other metals to which the electrolytic refining process is quite applicable. This is a large field in which electrometallurgists are already working; antimony and tin, for instance, have been worked on in this way. The general principles explained are applied, with differences in detail, to each one of the metals, enabling one to obtain the purest metals that have ever been put on the market.

If you electrolyze a solution with an insoluble anode, you can extract the metal from the solution without replacing it by metal from the anode. There are a number of promising electrometallurgical processes included in this class of electrolytic processes.

1. When you dissolve the gold from gold ore in potassium cyanide solution, the next problem is to get it out of solution. The

tons of ore a day. An immense body of ore is to be treated by this method.

You can get an idea of the importance of these methods of electrolysis with insoluble anodes from the few instances given. These magnetite anodes may also be quite useful in other electrolytic processes. In the generation of oxygen, for instance, they may find it practicable, for there has been trouble with anodes becoming corroded. I saw last summer, in Butte, an operation of the same kind, of the Butte and Duluth Company, plating copper out from sulphate solution and regaining the sulphuric acid for use again. The Phelps Dodge Company, which runs large copper mines in Arizona, has begun to study this method for its lowest grade of ores, and the main solution of this question rests on the use of insoluble anodes of fused magnetite.

We will next consider the question of the *Fused Salts.* In nature we find a number of metals in the state of salts which are fusible and which can be electrolyzed—sodium, calcium, and magnesium are obtained directly by the electrolyzation of those simple salts. Common salt, for instance, is only worth a few dollars a ton. If converted into metallic sodium on the one hand and chlorine gas on the other, one worth several hundred dollars per ton and the other worth fifty dollars a ton, you can see there is a great economic gain. The value of the product is out of all proportion to the cost of the raw material, and the cheapest way to do it is electrolytically. We have, therefore, numerous sodium works manufacturing sodium and chlorine from sodium chloride. Sodium fluoride is a stronger salt than sodium chloride and if mixed with the latter is not decomposed by the current because it is a weaker salt. The sodium fluoride keeps the melting point of the bath down and enables them to work it at a lower temperature, and thus get a better return of sodium. The uses for sodium increase greatly as the price goes down. Up to a couple of years ago, sodium makers were using caustic soda, $NaOH$, costing about $40 a ton. That was costly and increased the price of the sodium, but by going back to the original sodium chloride and finding electrolytic methods by which it could be utilized the cost of the metal has considerably decreased.

Calcium chloride occurs to a small extent in nature, but should properly be classed as an artificial salt. We have here an interesting illustration of another method of electrolyzing a fused salt.

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it with iron he could greatly increase the spark-giving property, so as to make it useful in those little cigar-lighters with which we are all familiar. The alloy used in those lighters is made from the waste cerium oxides, dissolved in fused fluorides. It is put into an electrolytic bath in somewhat the same manner as a chloride. The other rare metals (lanthanum, didymium) are allowed to stay in because they do not injure the quality of the alloy.

There is no works manufacturing cerium at the present time in this country, but I visited such a works at Treibach in Austria last year, and I understand that Dr. Fattinger has been over here considering where to put up a plant to manufacture these alloys from the residues which are in the yards at Gloucester, N. J. This industry employs three or four thousand workmen in Austria, and there is no reason why we should not have a similar industry over here.

I mention zinc here because a great deal of mone
spent in trying to manufacture zinc chloride and the
lyze it. The idea is to treat those complex sulphide

contain zinc with chlorine gas, converting the zinc into chloride, separating it from the other chlorides, purifying it, and the forming of it a bath, electrolyzing it, and getting back the chlorine, which is used again in the early part of the process. The ores are so complex that the operation has not yet been made a commercial success.

Electrolysis of solutions in fused baths is a principle which was discovered by Mr. Charles M. Hall and has been the foundation of the whole aluminium industry. It costs considerable money to get pure aluminium, but if you do not get it pure it is useless for many purposes. Mr. Hall was trying to decompose alumina, Al_2O_3, electrically, and he conceived the idea that if he could find some fused salt which would dissolve it the problem might be solved. Cryolite from Greenland is used for that purpose. It looks like wax or ice; its name—"cryolite"—means "ice-stone." It fuses at 1000° C. and when fused it is as limpid or clear as distilled water. Alumina dissolves in it like sugar in water. Take such a solution, put electrodes in, pass the current through, and you get out aluminium. You have to replenish the alum na as the supply in the bath becomes depleted. This invention of Mr. Hall is the cornerstone of the whole aluminium industry. There is probably 150,000 horsepower being used to manufacture aluminium. The output last year was something like 65,000 metric tons, of which about 40,000 were manufactured in America. The extent of this infant industry is amazing; it replaces three to four times its weight of the metals with which it is competing, because of its very low specific gravity. The output of copper in this country is now about 500,000 tons a year and is nearly stationery, while the output of aluminium, starting with almost nothing, has been doubling nearly every year. Last year, including Canada, the American output was estimated at 69,000,000 pounds. The commercial importance of this should appeal to us; I believe that aluminium is going to give copper a hard race. There is considerable more margin for reducing the cost of aluminium and selling it at a lower price than there is for copper. When copper gets below eleven cents a pound, many mines have to stop producing, but aluminium can be sold at a profit at a price lower than the cost of one equivalent amount of copper.

We now come to the electro-thermal methods and electric furnaces.

The electric furnace was first used to fuse metals. There are different kinds of electric furnaces; you can class them broadly into resistance furnaces and arc furnaces. Resistance furnaces can be subdivided into the direct resistance furnace and the induction furnace. The direct resistance furnace is one in which the material is heated directly by the passage of the current through it, while in the induction furnace it is heated by an induced current. In the arc furnace, where you use the arc, there is also some heat generated by the resistance of the electrodes, and some by the passage of current in the materials, where the arc jumps to the materials. The resistance of the arc, however, will account for 75 to 90 per cent. of the heat generated.

The fusion of metals was first tried by Siemens in England. He used a little crucible, making the bottom of his crucible one electrode of his furnace and the other terminal an electrode entering from above. He published his paper before the Institute of Telegraphic Engineers in England, because he could find no other scientific society interested in it. He rigged up a little automatic regulator to keep the arc constant, and his idea was to melt steel directly in the crucible, a crucible full at a time, by electric heat. In some of his tests he obtained about 50 per cent. thermal efficiency for the purpose desired, i. e., the heat in the melted steel was some 50 per cent. of the heat equivalent of the electrolytic energy used. His furnace never went into commercial use, but it was followed some twenty years later by the furnace of Mr. Heroult in the Savoy, France, who was the first to have the idea of fusing steel in a large furnace. Girod also constructed a practicable steel melting electric furnace, and there are several forms of successful induction furnaces. Within the next five years Mr. Hering's resistance furnace will also be making steel. Electric furnace steel is rapidly replacing crucible steel; it will probably replace it entirely in the next ten years. All steel could be benefited by a short sojourn in the electric furnace, and the latter will come into large use as an adjunct to the open-hearth steel furnace and the Bessemer converter.

Mr. Hering's resistance furnace uses small pencil-shaped resistors, filled with molten metal, and transfers the heat generated in them to the molten metal bath. The circulation in and out of these resistors is so active, because of the "pinch" force and its attendant "squirt" effect, that their temperature does not get excessive, and

the heat generated in them is rapidly transferred to the main bath. I have seen this furnace working very prettily on brass and cast iron, and I believe it has as promising a future as any electric furnace.

The Stassano furnace is a typical arc radiation furnace. It is usually run by three-phase current, the three arcs being kept clear of the bath of metal, which is heated by direct radiation from the arc or indirect radiation from the roof. The three electrodes are a little above the surface of the bath, at equal angular distances and with an arc springing between them. But in practice the arc may easily pass to the bath because of the metallic vapors produced in an intense heat like that. The air in the furnace becomes quite conductive from silicon, manganese, and iron vapors, so that you can have a 6-inch arc with about 90 volts across the phases; it is similar to a mercury arc.

The induction furnaces, of which there are several variations and types, are a great triumph of metallurgical and engineering art. I have the greatest respect for the man who first built a furnace like a transformer, with only one secondary turn, put a primary right in the centre of that ring, and succeeded in keeping it cool enough so that it did not melt the insulation on the wire, and transmitting the magnetic flux through the intervening space and materials to the metal which was to be melted. I regard the induction furnace as a marvel of engineering construction, and it was fortunate that it has been taken up by the Germans. It was first worked commercially in Sweden, but was devised years before by Mr. Colby, of Newark, N. J., who tried it but did not make it a commercial success. Mr. Kjellin, in Gysinge, Sweden, did it commercially, and then the Germans took hold of it and stuck to it, improved it, and with their great tenacity have overcome the difficulties and made the induction furnace better than I think any other nation could have made it. Many have thought that the induction furnace would drop out of the race, but the German is coming along with some further improvements all the time. It is better adapted for melting and keeping the steel melted than for refining the steel. It is not very well adapted for refining the steel because of the limited surface exposed. The Germans, however, are overcoming even that difficulty and have arranged a large open bath in the centre of their furnace, a bath in the middle where there is room for the action of the chemicals on the steel for refining it.

Mr. Paul Heroult was the first one to melt steel commercially in an electric furnace. He was not a steel maker; he was an electrical engineer, and he used to say, "I do not know anything about steel, but I am going to learn." I think he succeeded by learning some short cuts. You know we frequently are handicapped by knowing too much about a thing. He made a new flux and used the arc; he used it "without knowing that some things could not be done," and he did them. His furnace was nothing more nor less in outline than an open hearth furnace. His idea was to build a tilting open hearth furnace and to put his two electrodes through the roof above the bath. The idea of putting two arcs in series, with the bath as an intermediate conductor, was novel. Heroult patented the idea of melting steel by two electrodes in an electric furnace, passing the two arcs through a layer of silica slag. Mr. Heroult's furnace has been improved upon or modified by Mr. Girod, who uses only one upper electrode and conducts this lower electrode through the hearth of the furnace, so that he has only one arc, and takes off the current through the one electrode running through the hearth of the furnace. These electrodes in action are partly melted, about half way down, and the rest is solid. They are quite permanent; I have seen some of them which ran eighteen months. The steel metallurgist would be the last to dare to make a hole in the hearth of his furnace and put an electrode through the bottom. But that was where the electrical engineer put it, and there has been no trouble whatever with those electrodes. Right where the electrical engineer put them would have been the last place the metallurgist would put them.

Concerning the reduction of compounds to metal in electric furnaces, I have time to pick out only a few characteristic examples.

Boron is one of the rarest metals, but its compounds are abundant. It is made by bringing a volatile boron salt with hydrogen gas into an electric arc, where they are heated to a very high temperature. The salt is reduced by the hydrogen to metal, and the vapors produced are chilled before they have a chance to recombine. It is the same operating principle as is used in the fixation of atmospheric nitrogen in Norway. This boron is being put on the market for use in casting "conductivity" copper. This is one of the most recent productions of the electric furnace.

In Niagara Falls, Mr. Tone is reducing ordinary silica sand, SiO_2, to metallic silicon. This gentleman once took me into the

carborundum works at Niagara, showed me a barrel containing some thing, and told me to guess what it was I made two or three vain guesses, and he finally told me it was silicon, which, he said, "we can make for a few cents a pound." At that time metallic silicon was quoted in commercial price lists at $4.00 a gramme ($18.00 per pound). He said he wanted to find some use for it. Silicon is somewhat volatile, and 25 per cent. of that which he puts into his furnace goes up in smoke. He is now making silicon at Niagara Falls by the ton. Silica is mixed with carbon, put into a furnace heated by a carbon resistor, the mixture of silica and carbon being piled around the resistor, and the metal filters down around this resistor and runs out something like slag. It is being cast into vessels for use in chemical works. Thus is the most abundant element on earth now commercially available at a price of about six or seven cents a pound. One can only speculate as to the large future uses of it; it is made from the cheapest materials; the reducing agent is cheap carbon; and you have metallic silica from the electric furnace.

The zinc industry is attracting a great deal of attention. It is, apparently, one of the least progressive of the metallurgical industries. Little bits of retorts are heated to a high temperature, a few shovelfuls of roasted ore mixed with carbon are put into each retort and left there for 24 hours. Everything is done in a very homeopathic way, and yet it is so difficult a metal to handle that it is only by holding fast the ground gained that it has reached its present status. The electric furnace zinc industry has been made successful in Europe; there are works in profitable operation in Norway, Sweden, and Finland, while much skillful experimenting has been done in America. Last year 4000 horse-power was being used in producing zinc in Scandinavia, and 7000 horse-power has been added since then. The firms are very reticent about their methods; in fact, there is no reliable published data about their present type of furnace.

The manufacture of ferro-manganese, ferro-tungsten, etc., for making special steels, is done almost entirely in the electric furnace. The oxide of iron is mixed with the oxide of the metal to be reduced, with sufficient carbon for reduction. It takes about half a horse-power year to produce a ton of 50 per cent. ferro-silicon, for instance. The chief seat of this industry is the Savoy, in France, but the industry is gaining ground in the United States and Canada, and

imports are decreasing. Stassano, in Turin, was the first to make such alloys, using his arc-radiation furnace, but enormous furnaces (Helfenstein's) of 5000 to 10,000 horse-power are now used in this industry, which thus led up to the electric furnace manufacture of pig-iron and pig-steel.

The manufacture of the cheapest metal we have from the cheapest ore we have by electrometallurgical processes is, I suppose, one of the greatest triumphs of electrometallurgy. The electric current can really be used for doing what is now done in the blast and it is possible under some circumstances to replace it by an electrometallurgical furnace; that is the last triumph of electrometallurgy.

In one little place in Sweden that I visited two years ago, charcoal was getting scarce and they were importing coke from England to run their blast furnaces, and the quality of the product was not that of iron made with charcoal. They were much interested in the electric furnace, because it requires only one-third as much fuel to make a ton of pig-iron as the blast furnace. In their blast furnaces, with the charcoal available, they could make 300,000 tons of pig-iron, but in the electric furnace they could make 900,000 tons with the same fuel; so that was one of the inducements to use the electric furnace. The Swedes spent a quarter of a million dollars before they had a successful working furnace. They did their work in a most scientific way all through, watched their temperatures and all the conditions, and knew exactly what they were doing all the time. As a net result, they made pig-iron in the electric furnace as cheaply as they can in their blast furnaces. The Jern Kontoret (Iron Masters' Society) bought the patents for the furnaces, so that they became the common property of all the ironmasters of Sweden, and they have been putting up furnaces pretty rapidly. The last one was designed for 12,000 horse-power. It has been running for nearly a year at from 6000 to 8000 horse-power, making 55 tons of pig-iron per day. If it were run at full capacity, I think they could make 100 tons a day, which is equal to the average capacity of one of their blast furnaces.

At Domnarfvet and Hagfors, in Sweden, the same thing is pending. At the latter works they calculate that with this large furnace there is a margin of $2.50 per ton on the cost of pig-iron, to the advantage of the electrical furnace over their blast furnaces, so that electric furnace pig-iron is being made at a profit and cheaper than it could be made in the blast furnace in Sweden.

The possibility of making a product from this furnace which is not pig-iron, but which, as far as carbon content is concerned, will have to be classed as steel, has been proved. That product, with less than two per cent. of carbon, is in reality impure steel and not cast iron. It requires only a small amount of refining to bring it to pure steel. With the excess of iron ore present in the furnace you can make a low-carbon product. With electricity to furnish the heat, you can regulate the carbon so as to make a product with only two per cent. of carbon. This is a possibility with an electric furnace, but it is not a possibility with the blast furnace. We can thus make pig-steel, with less than two per cent. carbon, which can be converted in the open-hearth furnace into pure steel in about half the time that the ordinary product of the blast furnace takes. This will bring advantages with which the blast furnace cannot possibly compete. In the case of the problem being worked out, pig-steel will replace pig-iron for the manufacture of steel; this opens up the possibility of the electric reduction of iron ore going into use in places where otherwise it would not go if the product were simply pig-iron. It may come into Canada or along our northern borders, where water power can be obtained cheaply, for there is the large expenditure of 3000 horse-power hours per ton of product to be reckoned with. This will be the next great advance in the electrometallurgy of iron and steel.

DISCUSSION

A MEMBER.—I would like to ask why, in the reduction of silicon, the resistor is not consumed as well as the carbon which is used for reducing the silicon?

A. The resistor does get corroded, but the mixture contains sufficient carbon to take all the oxygen of the silica. Undoubtedly some silica gets against the resistor and eventually it corrodes away, but there is always more than enough carbon used.

MR. HENRY HESS.—I have a few questions on which I would like a little information:

The question of charging a furnace was brought up. Electric steel furnaces are mostly charged with cold metal. I was told somewhere that the use of molten metal would be better.

I think Professor Richards spoke of the Stassano furnace, of the current going down in the bath rather than between the two electrodes. We have a little furnace, and we found the trouble particularly great when the cold charges have been put in, and allowing the heat to get up fairly high; but when the charge is once liquid and kept down to the level at which it ought to be kept there is practically no jumping of the arc. The electric one-ton furnace that we have is

supposed to run with 1100 K. W. with cold metal and with a cold furnace, and for the second and third charge they were started with 900. The expectation is that it will run lower than that, to about 700 when it is working in good order, but the guarantee is for 900.

There has been recently an effort to improve the furnace. It is a very simple furnace apparently. It has only one top electrode dipping into the bath, and one bottom electrode. The figures given for that were 500 K. W. H. per ton. That does seem to me to be something extraordinary Is that a possibility in these days for a one-ton furnace? It is true they would give no guarantee as to the refining action of the metal it would take out.

Referring to the last possibility, pig steel; that is called impure pig steel; but since rather impure materials compared with what you want to get out are put into an electric furnace, and you can in that furnace refine to almost any degree you wish, why is it not practicable to carry that pig steel to a further degree and put it into the electric furnace again? Why not go direct to that?

PROF. RICHARDS.—The reason it is not done directly is because the steel furnace is essentially worked intermittently. You make your steel in batches, and when you have it right you pour it out. This furnace is worked continuously, and you cannot obtain a product like that; it requires an intermittent process.

MR. HESS.—Why don't they pour it into another one?

PROF. RICHARDS.—They do that. The steel was made from the cold metal but it could just as well be put in fluid. They are building electric steel furnaces alongside the other furnaces to take the product direct.

As for the requirement of 500 K. W. hours per ton of steel in Mr. Snyder's furnace, I think that is entirely possible. The heat insulation is well studied out, and it takes practically 375 K. W. H. net to melt a ton of steel; if they use 550 they are getting an efficiency of something like 70 per cent. That does not, however, leave much time for refining.

As to the work in the Stasanno furnace, if the electrodes are high enough above the bath and close enough together, the arc keeps clear of the bath; but when the arc jumps to the bath, as it does in Mr. Heroult's, then you have the principle of the Heroult furnace—arcs in series, with the bath as intermediate conductor.

You have asked whether the use of partly refined liquid metal in the electric furnace is patented. Mr. Heroult claimed that it was covered by his patent. He asked me out to see his furnace in Chicago, and I took the stand with Mr. Heroult at that time that his patent did not cover it, and I am still of the same opinion. He stated positively that it covered it, but I have studied the patent situation very carefully, and I have come to the conclusion that it does not.

DR. H. M. CHANCE.—I would like to ask Professor Richards whether he has any data on the consumption of electric energy in the operation of large furnaces, in the refining processes?

A. It depends on how long the refining lasts. If it lasts one and a half hours on fifteen tons, then it would take 1500 K. W. hours. That is 100 K. W. per hour per ton. If the operation lasted two hours, then it would take 200 K. W. hours per ton. With larger furnaces, properly heat-jacketed, it should be run with about half this heat requirement. I believe some of the large furnaces abroad are

using as low as 65 K. W. per ton to keep the steel melted, without raising the temperature. That includes the necessary refining operation, which lasts one hour. This is the lowest I have seen.

MR. HESS.—Referring to the heat jacketing; that furnace we have there, you can, primarily, almost keep your hand on it throughout the entire operation of the furnace, and we attribute the greater heat in the vicinity of the doors rather to the induction in the flue of the doors rather than in the induction of the material. And the losses in keeping the electrode holders cool are not very great, having a running stream of about one-half inch at twenty pounds pressure. It is fairly warm above the ordinary temperature. That is not taking off any enormous amount of heat.

DR. CHANCE.—With the electric consumption of energy, amounting to 2400 K. W. H. for the production of pig iron, how is it possible to harmonize this, with the statement that it looks as though the electric furnace was to replace the ordinary blast furnace in the near future. If we have our electrical energy at no cost, even at one and one-half cents per K. W. H., we have a cost of $12 per ton electric energy. The cost of blast furnace fuel is less than that.

A. The cost of fuel in blast furnaces in Sweden is about $5 per ton, and the cost of electric furnace power is one-tenth of a cent per K. W. hour. That is also what it costs in Norway.

DR. CHANCE.—I do not think we can hope for anything like that in this country.

PROF. RICHARDS.—You can purchase in Norway any amount you want at one-tenth of a cent per H. P. hour. In that connection in may be interesting to state that the actual cost of power in Norway, in the larger plants, is somewhere between $4.00 and $5.00 per H. P. year. It costs a little more in Sweden because the water falls are greater in volume but not so high, and the installation cost is higher. The power in Sweden costs ordinarily from $7.00 to $10.00 per H. P. year. You can buy it at $12 per H. P. year from the government, but the costs average nearly 50% higher than in Norway, where the cost of development is very small and is from lakes just a little way back from the sea at a great height, and the installation can be made at minimum cost.

MR. HESS.—There are electric public utility corporations who sell electric current at something under one-half cent to small users in this country.

Q. Where?

MR. HESS.—In Detroit for one place.

DR. CHANCE.—At those places, where you have used nominally low costs and where they have surplus power to sell, as a rule they can find no consumers. In this country we have water powers existing, and the owners of such water powers can usually find a market at a much larger price than you quote. The question I asked had reference to this country. We have a market for electrical energy in this country, and it costs something to develop it, and I do not think you will find many hydro-electric companies of this country willing to furnish power at much less than 3 or 4 cents per H. P.

PROF. RICHARDS.—I know several places in this country where it costs $7.00 to $8.00 per H. P. year; that is for self costs.

Dr. Chance.—At Sault Ste. Marie they advertise power.

Mr. Swaab.—The P. R. T. in this city say they produce current for 0.8 cents, but that is without the overhead.

Mr. ———.—I would like to have described the degree of purity obtained in the manufacture of tungsten and the use of alloys in the manufacture of so-called high speed steels.

Prof. Richards.—If you mix the tungsten oxide with iron oxide and sufficient carbon and put them into an electric furnace, you get a ferro-tungsten rather high in carbon. It is not suitable for making a low-carbon steel product, for which you need a low carbon ferro-tungsten, but this carbon can be burned out by the use of more oxide of iron. By the use of aluminium and in the absence of carbon, a low-carbon ferro-tungsten; the best is probably made by the Goldschmidt method.

Mr. Chance, Jr.—There is one point which I think is hardly fair to hydro-electric propositions. We are interested in a water power of 300 feet head, and there is a chance there for electric furnace construction. We cannot do much better than $120.00 per K. W. as the cost of installation, or a total at $9.60 per K. W. year, with insurance, etc., if you do not figure any thing on your maintenance, and one per cent. load factor, so we cannot get anything like one-tenth of a cent per K. W. H. But I think there is a chance to bring the furnace into use, especially in a case of this kind. When the iron market gets bad, you have to buy your current and pay for it. If it were possible to put in a furnace making pig steel, there might be a possibility to work it commercially. We have a case in Northern New York of an electric furnace that is making alloys, and we understood that they could take anything and put it into the furnace and get just about what was wanted out of it, at low costs. I would like to know whether this has been experienced by others?

Prof. Richards.—Conditions in this country at the present time are not favorable in general to making electric furnace pig-iron, but I think there are a few localities where it may be favorable for making pig-steel. There is a plant in North California which is making electric furnace pig-iron at a low cost. It is possible to use a high phosphorus ore and get a low phosphorus product, because the crucible is lined with basic bricks.

Mr. Chance, Jr.—You said that with 8,000 H. P. the output was 55 tons a day. That figures out about 35 H. P. per ton.

Prof. Richards.—If my memory serves me, I said that from 6000 to 8000 H. P. had been used, and the output averaged 55 tons a day. It figures out something like 3000 H. P. hours, or 2400 K. W. hours per ton. It is a striking example of how not to run an electric furnace, because if you run a furnace at half its capacity its specific power consumption is going to run up enormously. That furnace run to its capacity would probably make 120 tons a day at 2500 H. P. hours per ton.

Dr. Chance.—We have recently had before us some little problems of this kind. Up in New York State we have charge of a mine producing a very high grade concentrate. For feeding an electric furnace, we could run the concentra-

tration up to 69% product, so we would only have 3 or 4% impurities in that ore to take care of. That ore is extremely low phosphorus. Whether we run the concentration up to 69 or 70%, we get .606, so that the ore will produce what is known as a low phosphorus pig; we pass down below the decimal limit of phosphorus, and we can get it about as low as water powers usually can. There is a concern at Plattsburg, N. Y., and they have made some very beautiful metal from our concentrates. We have gone into the matter at considerable length, and we cannot see exactly where there could possibly be any profit in the operation unless the current can be utilized at times when it was not needed for other purposes. Unless we could utilize the electric furnace for other purposes when it was not required, then it might make out all right under present conditions, but as a straight out proposition we have not been able to see our way in advising people to spend their money in experiments of this kind.

PROF. RICHARDS.—How much does that power cost you?

A. 0.4 cent.

PROF. RICHARDS.—0.4 cent is $35.00 per K. W. year, which is something like $26.00 per H. P. year, and you can buy power at Niagara for $25.00 at the upper Falls, and $15.00 in the lower Falls, and you can go to Welland and buy it for $12.00.

MR. CHANCE, JR.—Yes, but we have to buy our current and we have to figure our total power product on our load factor.

DR. CARL HERING.—If you have power to sell, you sell all that you can for lighting and traction purposes, because that is required for certain hours of the day when you can get high prices for it, and they sell the power required for light load for electro-chemical processes for less than 0.5 cent per K. W. H.

PROF. RICHARDS.—I know of a small furnace which is making steel castings at a profit, and the power costs one cent per K. W. H., but there are electro-chemical works which could pay one cent per K. W. H. and make a profit.

DR. HERING.—There are concerns in Pennsylvania which can sell power for half a cent for traction purposes; but it does pay to let your furnace cool down.

MR. HESS.—I am buying current intermittently now. Our contract is 1.25 cent per K. W. H. for the regular use of the plant. For the current used in the furnace, except in winter, from 5 to 11 P. M., we can get them down to something like .8 cents per K. W., and they are willing to furnish us that from a small plant, and when we are using that we are taking more than half their entire product. They are willing to put in more plant to take care of us. And it is one of our public utility corporations, and I do not think we will accuse them of running a philanthropic scheme.

MR. HAROLD GOODWIN, JR.—I wanted to speak of the off-peak business between the hours of 4.30 and 5 to 7 o'clock in the evening, especially in the fall and early winter. The rest of the time they have that capacity standing idle. The electric furnace has the disadvantage which Mr. Hering has spoken of, in having to keep up the heat for that period. I would like to ask about the electrometallurgical process, particularly that of copper refining, whether the tempera-

PAPER No. 1144

THE WATER SUPPLY OF ANCIENT JERUSALEM

By HENRY LEFFMANN

October 3, 1914

Recent investigations have shown that Jerusalem was a point of great strategic importance at an early date. The origin and meaning of the name have not been positively established. The city has suffered, probably, more severe vicissitudes than any other city of the ancient or modern world. It has been the object of many sieges, and has been often captured and practically destroyed. In the second century of the common era, its inhabitants were involved in a rebellion against the Roman Empire, and it was taken by the Emperor Hadrian, who determined to annihilate it forever, drew the ploughshare over it, and re-named the site "Aelia Capitolina," but this effort failed, and the name is known only to the antiquarian and historian. An interesting fact stands out in the history of its sieges, namely, that, although the inhabitants suffered much from lack of food, they had abundance of water, while the besiegers as a rule had the reverse conditions. The region around Jerusalem is very sparsely watered, and, at an early date in the Jewish occupation of the city, means were taken to secure water supply within the walls and also to divert any supplies from without.

Information concerning the water supply of ancient Jerusalem is obtained partly from the Hebrew and Greek scriptures, but largely from the results of excavations, especially those carried out under the auspices of the Palestine Exploration Fund, the quarterly reports of which contain a large amount of interesting data. A number of comprehensive works are also available. Maps, topographic, geologic, and of other types, have been issued. Of late years, facilities for tourists have been greatly increased, so that thousands of visitors from all parts of the civilized world are constantly streaming through its gates. It is well known that the railroad leading from the coast to Jerusalem is operated by locomotives built at the Baldwin Works.

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Phenician sailors entered the
hundred years before the beginning of the present era, Phenicians in the service of one of the Egyptian kings made a circuit of the continent of Africa. The commercial supremacy of Phenicia, especially of Tyre, finds vivid expression in several places in the Old Testament, notably in the 27th chapter of Ezekiel, in which the city is compared to a ship and its fall and desolation predicted.

An interesting point is that the Dead Sea, which lies but a few miles to the east, is the lowest inhabited point on the earth's surface, being about 1300 feet below the Mediterranean datum.

It is obvious that no large supply of potable surface water could be secured from such a region. Reliance must be placed on subsoil or rain water. Both sources have some objectionable features. Subsoil waters are often rich in mineral matter, and in populated regions are liable to serious contamination. Rain water, though nominally distilled, is contaminated with suspended matters from the air and roofs, and is rarely of high purity in a practical sanitary sense. Ancient engineers knew almost nothing about the manner in which water produces disease and had no methods of purification except storage or by use of interrupting chambers that woul

mit some subsidence. Interesting examples of the latter are seen in the Roman Aqueducts, and are figured in my paper on the "Water Supply of Rome," published in a former number of the Proceedings of this Club (Vol. XIII, No. 2).

It is believed by the authorities that the earliest efforts at impounding natural waters for supplying Jerusalem were in Solomon's time (1000 B. C.). A reservoir was built in the Kedron valley—east and southeast of Jerusalem—for supplying water to the royal

Map of Southern part of Jerusalem at the time of the siege by Titus (about 70 A. D.).

The early conduit is shown in the upper left hand corner, the tunnel of Hezekiah in the lower right hand corner and also the possible course of Pilate's Aqueduct. (From Conder's Jerusalem.)

gardens. This reservoir, called by Josephus (War Bk. 5, chapter 2) Solomon's Pool, has not been identified. Later, an open channel was cut in the rock of the west slope of the Kedron valley, by which water was led to a point at which it was available to the inhabitants of the city. It has been suggested that the text in Isaiah viii.6, "the waters of Shiloh that go softly," is an allusion to the flow in this conduit, which has a slight grade. The original channel was identified in 1866.

"End of the Boring. Here is an account is the boring. While the borers worked their picks in opposite directions and there were three cubits to break through, they heard each other's voices, for there was an overlap found in the rock on the right and left, and on the day of completion the borers faced each other face to face. The waters ran from the pool spring twelve hundred cubits. The height of the rock above the borers' heads was one cubit."

My suggestion relates to the word "overlap." The word in the original is uncertain and several meanings have been proposed. It seems to me that the translation I give meets the conditions. From the illustration it will be seen that the tunnel pursues a remarkably tortuous course. The only explanation that has been offered for this course is that it was necessary to avoid rock tombs that had already been established.

The spring was intermittent and has even been supposed to have symbolic periodicity. It is an interesting example of how a legend may arise and be propagated that a traveler who visited Jerusalem in the year 333 of the common era, and who is known to historians as the Bordeaux Pilgrim, states that the pool was inside the walls of the city and water did not flow on the Sabbath.

Excavations along the southern wall of Jerusalem have brought to light an aqueduct passing along the northern slope of the Hinnom valley, penetrating the wall and passing to the southwest corner of the city. This aqueduct is well built, being hewn out of a rock-side with rather steep incline, the upper and lower sides being extended by walls so that flat stone covers might be used. The cross section of the channel is rectangular, with a depression in the center line of the floor. The dimensions are about three feet high and two and one-fourth feet wide. Rock-hewn manholes are provided. At one point there is a chamber five and one-fourth feet wide, four feet long, nine feet high. F. J. Bliss, whose excellent work on the excavations at Jerusalem gives much information, thinks that this dates from Solomon's time, but further investigation is required to decide this point.

In addition to these aqueducts, Bliss gives the lines of one beginning on the west of the city, passing around by the south in the Hinnom valley, and entering the city towards the east. This he terms the "Lower-water" aqueduct, but gives no special information about it.

We know from the historian Josephus that Pontius Pilate constructed or repaired an aqueduct at Jerusalem, the possible line of

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who might give us similar information about the Holy City. Sad, indeed, has been the treatment Rome has received in the course of human history.

> "The Goth, the Christian, time, war, flood, and fire
> Have sat upon the seven city's pride."

But Jerusalem has suffered much more, and today investigations are carried on amid an indifferent and even hostile population, through masses of rubbish that have been accumulating f
three thousand years, and after many occupations by hos
that have hardly left one stone upon another.

ABSTRACT OF MINUTES OF THE CLUB

BUSINESS MEETING, JUNE 6, 1914.

The meeting was called to order by President Swaab with 41 members and visitors attendance.

The Committee on Nominations, consisting of Carl Hering, chairman, Richard Gilpin, Richard G. Develin, Richard L. Humphrey, Thomas C. McBride, E. M. Evans, and W. P Dallett, appointed by the Board of Governors at their meetings of May 12, 1914, was accepted.

Owing to the inability of Mr. H. V. Schreiber to be present, Mr. Thomas H. Arnold read Mr. Schreiber's paper, entitled "The Power Problem in the Lehigh District," and then read his paper, entitled "An Analysis of Electric Drive in Cement Mills."

The papers were discussed by Messrs. Hering, Wood, and by Mr. Brooks, of the Lehigh Navigation and Electric Company.

A unanimous vote of thanks was tendered Mr. Arnold.

JOINT MEETING

Of the American Society of Engineers, Architects, and Constructors and the Engineers' Club, September 19, 1914:

Meeting was called to order by Vice-President Mebus, at 8:30 P. M., with 112 visitors and members in attendance.

The Secretary announced that the Board of Governors, at their regular meeting of September 15, had elected to active membership the following:

Frederick Lennig, D. Webster Anders, John H. Brown, Jr., and Addison Hutton Savery.

Mr. T. Hugh Boorman presented the paper of the evening, "Modern Road Building Here and Abroad," which was discussed by Messrs. Trautwine, Uhler, Furber, Boorman, and others.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS

Regular Meeting, September 15, 1914.

Present: President Swaab, Vice President Mebus, Directors Berry, Haldeman, Yarnall, Hibbs, Wagner, Worley, Andrews, Dunlap, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of May 12, 1914, were read and approved.

The Treasurer reported a net loss to September 1 of $202.45, as compared to a net gain of $2160.65 for the same period of last year.

A copy of the comparative income and expense statement was presented and the Board ordered that a copy be stricken-off for each member of the Board.

The Treasurer was authorized to bond the bookkeeper for the sum of $2500.00.

The President appointed a Committee, consisting of J. R. Bailey, Chairman, Joseph C. Wagner, and F. K. Worley, to make studies for the purpose of revising the system of bookkeeping in the Club.

The report of the House Committee was presented and appropriation of $100.00 was made for the purpose of purchasing linens for the house and restaurant.

The Membership Committee's report was presented and the following were elected to Active Membership: D. Webster Anders, John A. Brown, Jr., Addison Hutton Savery.

Mr. Yarnall, for the Committee on Co-operation, outlined the progress of the work and the methods which the Committee was pursuing.

It was moved and carried that an exchange of Club privileges be effected with the Engineers' Club of Dayton, Ohio, and the Engineers' Club of Trenton, N. J.

Application from the Delaware River Branch of the American Society of Marine Draftsmen was presented, asking for desk room in the Club house for the use of the Secretary, without charge. This was granted.

The resignations of H. V. Atkinson and Thomas E. Rodman were accepted as of June 30, 1914.

James Thompson's resignation was accepted as of December 31, 1913.

INDEX VOLUME XXXI*

*The January issue of 1914 was numbered Vol. XXXI, No. 5, and should have been numbered Vol. XXXI, No. 1.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA

VOLUME XXXII

EDITED BY THE PUBLICATION COMMITTEE

PHILADELPHIA
THE ENGINEERS' CLUB OF PHILADELPHIA
1317 Spruce Street
1915

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXII JANUARY, 1915. No. 1

PAPER No. 1145

AIR CONDITIONING

BY J. IRVINE LYLE

October 17, 1914

In these times when we hear so much about "Back to Nature" it is well to consider what nature gives us in the way of health. We men cannot improve very much on nature's best. Of course, if you pick out a bright sunshiny day in June, you would consider that as being about right. On the other hand, when we stop to consider a cold, bleak, humid day in winter, or a hot, sultry day in summer, I am inclined to think we can improve a little on nature. We cannot beat nature on a June day, but we can give June days the year round if we so make up our minds.

On the question of ventilation there has been quite a discussion in the last few years as to what we needed to improve ventilation. Such men as Briggs, Wolfe, and others have evolved certain standards which are almost universally used. There have been certain documents published by the health authorities, physicians, and others, and the problem has been attacked from various viewpoints; but so far all have failed to prove that the standards that have been adopted are wrong, or to provide a rational substitute for them. Some of them have recommended recirculation of air —of small quantities of air—and this leads one to wonder whether

seen machines, built by a competitor of copper, where I could stick my finger through the side of the washer. It all depends upon local conditions. In the Bankers' Trust Company of New York we put in a machine for cooling the banking room floors. Within a year certain parts of that machine were all apart. We jumped at the conclusion that the cause was electrolysis, but an analysis of the water showed 22 grains of free sulphuric acid. The water used is Croton water, which is alkaline, but after a few days' run it has sulphate in addition to the 22 grains of free sulphuric acid. This could not come out of the water so we concluded it must be taken out of the air. Just around the corner from the building was the Assay Office, and we were getting enough fumes from the assay office to give us this sulphuric acid in the air, and I do not know of what to tell you to build machines that will stand 22 grains of free sulphuric acid. We cured that case, however, in a simple way, by setting up float valves so that the water would go above the float and a certain amount go to waste; most people would not want to do that, but it is better to let a certain amount of water go to waste than ruin your machine, or they want to clean out the machine once or twice a week and put in fresh water all the time, or, if that is not feasible, make your machines out of galvanized American ingot iron. All rivet heads in our machines are soldered, and with ingot iron you have an iron that will not pit through. We have put steel in a place where galvanized American ingot iron gave way in four months. Black ingot iron coated with enamel has lasted for eight months without any trouble under a very bad condition.

Dr. Carl Hering.—You spoke of enamel; did you mean baked enamel?

Mr. Lyle.—No, it was self-hardened. I do not think baked enamel would be successful; for anything brittle would chip off, but being self-hardened any little bend in the shop would not crack it. In this machine in the Bankers' Trust Company we put in a new section of pipe; it was all put in brass with the exception of one piece covered with Bitumastic, and that has been in for about eighteen months. My point is that I do not know that there is any one metal which I can see is going to cure all ills. In one case they were getting water which upon being analyzed was found to be all right, but a second analysis showed they were getting sewerage.

of stoker with natural draught—there is the Murphy, the Detroit, and the Chain Grate, and the Rooney.

A Member.—These results that you have shown, are they all comparable with the original samples of the coal?

Mr. Hubley.—In regard to all the samples that we worked on, these samples were taken according to a standard method which goes with our coal specifications. It starts with 300 pounds on top of the car, taken according to an arbitrary method and reduced by crushing on a canvass to 75 pounds and put through a small crusher and a 10 mesh screen and riffles, and going through smaller riffles and over grinders with a 10 pound sample to a 60 mesh. We have a sampler at our new boiler plant which takes away absolutely the personal equation.

Dr. H. M. Chance.—Was that one great sample?

Mr. Hubley.—Well, we had three cars to each group. This was made of a two pound sample from each car and further reduced by riffles. As a rule the 2700° was specified. I have taken the arbitrary point at which the pellet collapsed to half its original height. In every coal I have tested, I find that at this point the ash is fusing at a very fast rate, and I have taken that arbitrarily and called it the fusing point, and incorporated it in the specification.

Mr. F. C. Freeman.—I would like to ask Mr. Hubley if the ash from coal coming from the same mine but in different shipments would at each time show the same fusibility? Would the variation of fusibility be very great?

Mr. Hubley.—In regard to that question, do you mean taking a sample from a different shipment?

Mr. F. C. Freeman.—Supposedly from the same mine.

Mr. Hubley.—We have found a variation from some mines. For instance, we differentiate between true ash and ash from the partings. Run of mine coal contains a good deal of coal from the partings. Some ash constituents would run high and others low in certain mines, especially in high fusing ashes. In other words, the fusibility of the true ash and "parting" ash will sometimes vary in a mine, therefore, the R. O. M. sample will be affected according to the variable percentage of "parting" ash contained in the R. O. M. sample.

Dr. H. M. Chance.—Mr. Hubley's paper is intensely interesting because it treats the subject in a way that makes it clear to those of us who are not mechanical engineers. It is interesting to learn that even from the standpoint of one who has done a vast amount of experimental work in determining the fusing point of ash that determinations of practical value are difficult to obtain by laboratory experiment. It seems that perhaps the best way to learn the fusing point of the ash of any coal is to burn the coal as in practice under an ordinary boiler. Those who are familiar with the mining of coal know that it is impossible to get a sample that will accurately represent the output from any mine. The taking of a sample from a single car of coal can not be expected to represent the output of the colliery from which it comes for any day, part of a day, or any fixed time. Nearly all bituminous coal is now mined by machines, usually driven electrically, and it is hauled by electric locomotives, in trains con-

Mr. E. B. Carter.—I would like to ask Mr. Hubley whether he has found the coals that run high in fusing points of ash, whether they are high volatile or low volatile coals?

Mr. Hubley.—As far as the Middle Pennsylvania coals are concerned, the high fusing ashes do not follow the lowest volatile matter, but the volatile ranges in my mind from 18 or 16 per cent. to 24. There is no particular law that I know of as far as the Pennsylvania fuel goes.

Mr. Carter.—Did you say 16 to 24 per cent?

Mr. Hubley.—Yes.

Mr. Carter.—That would not be up in the gas coals.

Mr. Hubley.—Gas coals apparently fuse at quite low temperature, that is, what few I have been able to experiment with, which were from the Fairmount District. I have only had experience with two or three of them.

Mr. C. H. Bigelow.—What method do you use for penalizing in coal specifications?

Mr. Hubley.—So far as we have been able to arrive at a way of penalizing, we simply fix on a minimum temperature at which fusion is to occur, and reject the coal which does not come up to this figure. I would like to hear any suggestions in regard to this. I have been casting around myself as to how this question should be handled. When you lower the fusing specification below 2600, as I said before, you should consider the viscosity.

THE EDISON AGGREGATE *January, 1915*

Reproduction of a letter written by Mr. Thomas A. Edison to President W. S. Mallory of the Edison Portland Cement Company. It speaks for itself.

Cable Address "Edison, New York"

From the Laboratory of Thomas A. Edison,

Orange, N.J. Dec. 16, 1914.

Mallory:

A careful estimate by engineers of the damage to our concrete buildings shows that 87% are in good condition in spite of the intense heat occasioned by the highly inflammable nature of their contents.

The brick and steel buildings subjected to the fire were entirely destroyed as also were their mechanical contents; of the machinery in the concrete buildings about 85% can be used after slight repairs. I consider this a triumph for concrete considering the fact these buildings were among the first built in this country before up-to-date methods of reinforcing were used.

Edison

FIG. 1.

$15. Insurance adjusters made their estimates of damage at a meeting held in this building the day after the fire which destroyed the rest of the plant.

Another notable concrete building tested by fire was that of the Dayton Motor Car Company, Dayton, Ohio. The heat became so intense as to melt down brass machinery parts, but the damage to the building was so slight that within two days after the fire occurred manufacturing operations were resumed throughout the structure.

Business Meeting, December 19, 1914

Meeting was called to order by President Swaab at 8:15 p. m. with 87 members in attendance. Secretary announced that the Board of Governors at their Meeting, December 15, 1914, had elected the following new members: Active Membership, O. H. Gentner, Jr., Aurin B. Nichols, Harold Pender, Percy F. Proctor; Associate Membership, Edward Lupton; Junior Membership, Alexander Broadhead, Leonard B. Gallagher, John B. Shallcross.

In accordance with Art. V., Sec. 2, of the By-Laws, the name of Mr. J. W. Ledoux was presented as a candidate for President. The official list is now as follows: President, J. W. Ledoux; Vice President, D. Robert Yarnall; Secretary, L. H. Kenney; Treasurer, J. Reese Bailey; Directors, Charles E. Bonine, William Irish, Jonathan Jones, and J. Chester Wilson.

The Proposed Charter and By-Laws of the Engineers' Society of Philadelphia were presented for discussion by Mr. D. Robert Yarnall, Chairman of the Executive Committee of the Engineering Cooperative Movement, and explained by Mr. Henry Hess.

After discussion the following resolutions was introduced by Mr. W. P. Taylor, seconded by Mr. W. C. L. Eglin, and unanimously carried.

Resolved, That the Engineers' Club of Philadelphia endorses the proposed Charter and By-Laws prepared by the Executive Committee of the Engineering Co-operative Movement.

Joint Meeting, December 19, 1914

Of the American Institute of Electrical Engineers and the Engineers' Club.

Meeting was called to order by President Swaab at 8:45 p. m. with 153 members and visitors in attendance.

Dr. Wm. L. R. Emmett presented the paper of the evening entitled, "Mercury Turbine," which was discussed by Messrs. H. E. Ehlers, Henry Hess, E. M. Nichols, Carl Hering, W. C. L. Eglin, and John C. Trautwine, Jr.

A unanimous vote of thanks was tendered Dr. Emmett.

Joint Meeting, January 2, 1915

Of the American Society of Marine Draftsmen, Delaware River Branch, and the Engineers' Club of Philadelphia.

Meeting was called to order by President Swaab at 8:40 p. m., with 53 members and visitors in attendance.

The scheduled speaker of the evening, Mr. John F. Metten, Chief Engineer, Cramps Ship and Engine Building Co., was unable to be present.

Dr. Henry Leffmann addressed the Club on "The Garden of Eden" using the first chapter of Genesis as the basis of his talk.

Mr. Percy H. Wilson, Secretary of the American Society of Cement Manufacturers, spoke on the recent fire in the Edison laboratories. Mr. Wilson showed many pictures of the progress of the fire and its effects on the building.

the water and sewerage problems and the housing problem and the water purification and sewage disposal problems generally of serious concern until the municipality has attained a certain size, as all of these problems are more easily solved and all of these facilities more easily provided for a small community than for a correspondingly large one, and, in the case of large cities, additional problems come up from time to time which were not a part of the original scheme and which become extremely difficult to correlate with the wholė. The dictum of the biologists can here be reasonably applied (as the City has been compared with the human organism) that an organism is not necessarily higher in the scale of being if it is simply larger or more complex. The former can exist under much more simple conditions and may therefore be compared in fitness with a more complex organism which requires more complex conditions under which to survive and thrive.

The small city with its simple problems can therefore well compare with the larger city in which every one of its physical problems is more involved and more complex.

to remember its deficiencies. It is not on
learned—the company itself has improved
of this apprentice course in the light of
years observation has yielded. The cour
complete than at its start.

The graduated learner, as stated, fi
which are unimportant and where he cann
His work then gradually increases in imp
of six months or a year of sales office wo
of some value.

In this system of training men for its
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system, the selecting of the right man is o
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indeed, on the contrary, the Company ha
the consideration of such applications as
out the particular man. At the present
respondence is being conducted with the I
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there is no gilded road to a sinecure in th
his associations for a year or two will be
to which he has probably been accustomed. It is made plain to him that his $60.00 a month salary is an investment on the part of the Company in his potential value and that he is expected to stay with the Company at least three years. But he is asked to sign no contract. His word, that it is his sincere desire to earnestly acquire a knowledge of the business, is taken as sufficient warrant of the integrity of his purpose. It is confidently believed that this system of training men is a success. Some failures have been experienced, of course, but the majority is far the other way. As previously stated, the start was made in 1900. At that time six men were admitted to the course of training. Three of those men are still with the Company, all have responsible positions, and one is the present General Manager of Sales.

PAPER NO. 1149A

TRAINING THE ENGINEERING SALESMAN

BY JOHN MEYER
(Commercial Engineer. Phila. Electric Co.)

February 20, 1915

Engineering salesmanship, so far as its relation to the Central Station industry is concerned, implies two separate and distinct features. The first, engineering, having to do with the mechanical or electrical design, or both; and second, commercial, that relating to the exchange or buying and selling of commodities for a profit.

The engineer without some commercial knowledge would be a failure as a salesman, and conversely a salesman without some engineering knowledge would be a sad failure as an engineering salesman. The success of the engineering salesman depends upon the degree with which these two elements are merged. The ideal would be a commercialized engineer.

The enormous increase of machine applications in the industries has required this type of salesman. A decade ago, the successful salesman was the one who made the most noise and spent considerable of the purchaser's time in entertainment. These factors are no longer essential. To be successful the salesman must furnish facts. The present day purchaser demands results which must be substantially measured in terms of dollars.

Considerable time and money is expended in preparing to do business. When, however, we face the problem of disposing of our product, we usually find that a very essential part of our plan has been overlooked, namely the selection of efficient salesmen. This condition prevails as well in old-established concerns.

The present plan somewhat tends to select men who have been successful salesmen in the hope that they may gain sufficient engineering knowledge to assist them in their new field. The more successful plan is to select, from the organization, men who have developed.

Operation and Costs of Electric Illuminants, such as Arc, Incandescent, and Vapor,
Relative Costs of Other Forms of Illumination,
Lighting of Residences, Theaters, Churches, Hotels, Factories,
es, Streets, and Spectacular Lighting,
Viring Campaigns,
Propositions,
Payment Installations,

Heating Appliances.

Power Salesman:

Characteristics of Direct-current and Alternating-current Motors,
Motor Applications,
Cost of Motor Installation and Operation,
Gas and Oil Engine Competition,
Special Industries, such as Refrigeration, Storage Batteries, and Rectifiers,
Industrial Heating Appliances,
Rural Business,
Isolated Plants,
Study of Steam-Consuming Devices,
Study of the Cost of Installing, Maintaining, Operating, and Appraising Isolated Plants.

Merchandising:

Current-consuming Devices,
Method of Introduction by Central Stations,
Method of Introduction by Others, such as Department Stores, Hardware Stores, Drug Stores, Wiring Contractors, Dealers, etc.
Display Rooms, Including Office and Window Displays.

Rates:

Application of Company's Rates,
Meters and Metering, Including Measurement of Electrical Energy, Types of Watt-hour and Maximum-demand Meters, Installation Records, Accuracy Tests, and Maintenances,
Rate Adjustment,
Commission Regulations,
Franchises,
Municipal Competition.

Wiring:

Systems, such as Two and Three-wire and Convertible,
Approved Materials,
Types of Construction,
Underwriters' Rules,
City Code,
City and Company Inspections,
Estimates for Lighting and Power Installations.

those of his competitor.

4th. A knowledge of the transaction wherein dwells the exercise of the practical act of selling—the consummation of the deal whereby property changes ownership.

The Psychology of a sales-transaction is that the purchaser's mind passes through four stages:

1st. Attention,

2nd. Interest,

3rd. Desire,

4th. Resolution.

It is that which is to be sold to which we wish to attract the customer's attention and in which we wish to arouse his interest. Any one can call upon a prospective buyer and go away again. But that is a different thing from actually securing attention.

The salesman who has won attention and can hold it and vivify it into true interest is already on the way toward persuading a customer to buy. It is also evident that the process of arousing interest, or developing it from attention, will depend on the article or goods the salesman has for his disposal. It is in his proposition that he wants the prospective purchaser to feel interest, and hence a mastery of the selling points gained by analysis will undoubtedly serve his purpose.

The salesman must create an earnest wish, longing, or aspiration for the thing he is selling. His analysis of the goods has made him familiar with all their merits and persuasive points. He has secured the customer's attention by the introduction, and, presuming this is a difficult case, he has by means of description, in his first selling talk, created a degree of interest in the goods. He has learned to present the merits of his goods in a clear and forcible manner and has so stated the points in the proposition that it already appeals to the customer in a measure. It is by driving home the points with which he aroused interest, together with the addition of fresh points, that he must strive to create desire to buy.

To sum up, reiterate some of the points brought forth to arouse interest; make these points plainer by illustration; select from analysis additional points not discussed in the other talks; bring in suggestive arguments to intensify conviction and desire. Remember that interest properly augmented will change to desire.

It is assumed that the salesman has secured attention and interest, and has created a desire, and it now remains for him to bring about the resolve to buy.

The whole purpose has been to get the customer to resolve to buy the goods, and then act. Right here is where many salesmen fall down, and much depends upon the training in class work and in the field. There are salesmen who were able to get attention, arouse interest, and even create desire, that is, it really seemed that the person to whom they were speaking desired the article, but they were unable to "close the deal." Inability to detect the "psychological moment," to recognize the instant when the customer's mind is ready to swing from desire to resolve-to-buy, is the cause of the failure of many salesmen. They cannot discern the "psychological moment." They keep right on talking and thus talk the customer into the sale and then out again. The

plants which should be supplemented by discussion of the particular features of the plant. The complete training that is required may be divided into three parts:

1st. Training in the principles of salesmanship.

This is accomplished by the class work, by actual demonstration in the class by experienced salesmen, by actual sales transactions between two of the students or between an experienced salesman and the sales manager.

2nd. Training in the construction and the application of the article to be sold and the results obtained by the engineering salesman who is intimately familiar with the details of the construction and operation of the apparatus.

This may be obtained to some extent by actual work in the various departments of the Company, to determine the operating condition of the apparatus the Company uses in the manufacturing of its

product; later a study of the appliances used in actual operation. As I stated before we are beyond the point where a salesman seriously enters into the sales transaction. What the purchaser desires to know is the ability of the apparatus to produce the desired result.

3rd. The training and special selling methods.

This training should be secured in class work, in the sales transactions between an experienced salesman and the prospect.

ment; if we can do it, it indicates that a certain article has been put upon the market and that you can get it at the regular assigned stores. What a needless waste of effort to do otherwise. It is well to find out what is selling, so that we can feel the philosophy back of what we are trying to do. I believe that why so many people fail is because they have not a philosophy back of what they are trying to do. If there is a philosophy back of it, it is up to us to get the essence that is there to apply it, to adjust ourselves to those principles and try to create value where no value existed

before, because, when we come to an intensive analysis of salesmanship, we know that it means creating value where no value existed before. How many people go out to try to sell goods where no value existed? They do a lot of work and get to a certain point, but the man they are trying to sell to fails to give an order. We have to get back of selling enough to feel that it is a factor in economic society and that selling is a force which is necessary to bring a new article into the hands of the community. People are peculiar in their mental attitude toward salesmen. If a new thing is thrust out, we look at it with suspicion. I well remember the first automobile that went about the streets of Chicago, where I then happened to be. The people looked at the driver curiously; but we do not do that today. Advertising and effort and selling get in their work until a "vogue" exists in the community, as it did in Chicago, and the people finally concluded that an automobile was a good thing. And now the proposition is how to get the money to get the automobile. But the mere announcement that an antomobile had been invented did not sell the automobile. I understand that when gas was first introduced in London, they said that we are going to drive smoke through pipes and burn it at the other end; the people all laughed at the proposition. Now they have electricity. The first man to wear a silk hat in London was followed by a horde of men and boys all pelting him with rocks, and he was arrested for disturbing the peace. Now if you do not wear certain things you are liable to be pelted with rocks or at least ridiculed. If we had some kind of physical being with pores that absorbed all the things that we ought to absorb, we would be as gods, and we would be up yonder somewhere; but we are human; we are here bound down by instinct and tradition, and if we have a "vogue" everybody says it is "the" thing, and when people say you have reached a high state of commercial development, you have gotten "vogue." That is what you want to work for with any article you want to sell, and you want to educate the people to anything you want to sell. That is where a great many make a mistake, by thinking that the people will take it for granted. The thing you have to do is to educate the people, and perhaps you will have to call on a man fifteen times to do that. It takes weeks sometimes in order to make a man see the relationship of the thing to his business of which it is a part. A man has to know where to advertise and when to get in salesmanship.

to getting over that particular proposition, they do not have those qualities within their nature. The man who has not the selling instinct ought not to go into that work or take up that particular vocation, and the man who does have that selling instinct ought not to get in a position where passivity exists.

Another idea, we are not expected to sell every individual that we come to. Some people think they ought to sell to every one; you are not expected to do that. Each one of us has a following in life; certain people respond to us and we respond to them. From a selling standpoint you ought to study yourself enough to know the kind of people or type of individual you can tend to influence in a given proposition, and, if you are selective, to the kind of people you will try to appeal to, and if you get one out of every ten, instead of trying to get the ten, you are going to save considerable energy. There are certain individuals who will tend to respond almost immediately, and others who will not do so at all. We have to understand that we must create a vogue, and know when to connect and absolutely drive that sale to a close. These general principles must be observed. First of all, we want to study ourselves and know our goods. We want to have absolute faith in the house we are working for, or else get in with another house if we are good salesmen. We want to recognize the fact that there is a sale between that individual and me; I have to know previously, before I approach him, all the facts concerning that man that I can possibly know. I must know even the things on his desk, the manner in which he addresses people, and the particular mood he happens to be in on that morning; I have to analyze that man, and that is the approach. Then I must get his attention, and I must not do so as many individuals do, look down on the floor and sort of talk as if you and I had analyzed the situation and of course you will have to see it. You have to transfer your personality and get the man over to your way of thinking. That sale in all of its detail must be studied, and when you are tending not to succeed it is up to you to ask the question: "Is my approach wrong, and is my demonstration not what it should be?" "Do I lack the ability to close a sale?" From an analysis from the most successful salesmen, the close should not be the most important part of the sale. The closing is the unfolding of the mental relationship that you have had with the buyer. A good many men talk themselves out of a sale that has already

Mr. John C. Trautwine, Jr.—These three papers, and Mr. Gillispie's paper in particular, contrasting former and still recent with present conditions, give us a realizing sense of the phenomenal development of great industrial corporations within very recent years.

As I have often maintained here, this development is part of the great evolutionary process by which humanity is passing from the relatively pure individualism of but little more than a century ago to that completely socialised state which can hardly fail of consummation within a generation or two, so rapid and so increasingly rapid is our progress in that direction, and so irresistible are the forces urging us thither.

Mr. Gillispie mentioned that, before the recent development of salesmanship on scientific lines, the salesman was regarded, even by the manufacturers themselves, as "a necessary evil"; and Prof. Hess admitted that, from a sociological point of view, "selling is a queer thing anyway"; and, at the risk of appearing discourteous to our guests, I venture to predict that, within a half-century (thanks very largely to the activities of our great corporations), society will have reached that stage where our more nearly civilized descendants will look back with amused wonder upon these semi-barbarous days of ours, and will see that the salesman was indeed "a necessary evil," and that selling was indeed "a queer thing anyway."

Even today, it ought to be easy to recognize that, whether really necessary or not, it is an evil that the entire community is taxed to maintain great and highly organized schools, where rival armies are trained in all the refinements of a still continuing war between the rival industrial armies, still maintained by the corporations, in default of that public industrial army into which these warring tribes must before long be merged.

Mr. Meyer noted the four successive stages (1, attention; 2, interest; 3, desire; and 4, action) to which the victim must be brought by the salesman who hopes to outwit his competitors and land the one thing needful—*The Order.*

Mr. Gillispie has mentioned that the student of salesmanship is encouraged to familiarize himself with the products of competing manufacturers. Is this in order that, when the customer is trembling on the brink which separates (3) desire from (4) action, the salesman is encouraged to begin dilating upon those points in which he knows his competitor's product to be superior to his own wares?

Prof. Hess mentioned the value which salesmanship is supposed to "create" by hastening the general use of inventions (he mentioned the automobile as an instance) which, otherwise, might have come more slowly into general use. He contrasted the activity of the automobile salesman with the modest silence of our general government respecting its own products. This calls to mind the topographic sheets published by the U. S. Geological Survey, and sold for perhaps less than one-twentieth of the price at which any private producer could afford to sell them. The fact that they are for sale for nearly nothing is pretty generally known to those who would be likely to make use of them; and they thus, practically without salesmanship, find the sale which the conditions warrant. Would it be better if government salesman went about the land unloading these maps upon reluctant farmers and milliners, and is it an unmixed blessing that thousands of our citizens have been led, by the salesman's art, to mortgage their all for automobiles without which, perhaps, they would have been better off?

Prof. Hess mentioned the distrust with which new inventions are regarded, and with which the salesman is usually welcomed into the office of the intended victim. I lately addressed the Jovian Electrical League upon the subject of "Sin, as a Symptom of Maladjustment," and Emerson reminds us that the presence of that "obscene bird," fear, surely points to the existence of carrion in the neighborhood. We distrust the salesman just because we know that he has been trained in a school whose express purpose is to teach him the noble art of giving a one-sided view to the question at hand. Distrust is the necessary outcome and symptom of a "business system" which puts its premium upon

a new line of stationery, and he called on a big fellow in the West, thinking to sell to him first and get him as a reference; but the big dealer met him with the statement that "we are using all that kind of material we war want to be bothered with a new line," refusing even to look at l fellow went back to his hotel and gave the matter some deep an He said to himself, "there must be something wrong with me; first thing he did was to take a bath; then he put on clean u shirt, a clean collar, everything—an entire change of clothing, back to the big dealer. He said: "Mr. ———, there was with me when I called on you this morning, and—" well, he told done, and he said, "now will you favor me by taking a look at my

the big man was very much pleased. He said "My, I wish my salesmen would be willing to go to all that trouble for me—certainly I will look at our goods."

The salesman knew he had to do something unusual to get favorable attention, and for the lack of that principle many sales are lost. When he gets favorable attention, as Mr. Meyer stated, his battle is almost won. Nature's laws are mighty, and that is just as absolutely a law as the law of gravitation, namely, favorable attention secured by doing the unusual thing in a constructive way. If you cannot get it that way, there is one thing that does get attention, and that is the personality of a man.

One other thing I want to say; that is, that salesmanship is going to be more a matter of rendering service. The essence of salesmanship is the power to serve to the end of the satisfaction of the buyer and the seller. As soon as you show the salesman that he has something by which he can render a service, the greater will his success be. We ought to begin to eliminate the thought of competition and think more about what to do to render this man a service. If I can render a better service I do not need to bother much about competition.

Mr. J. C. Parker.—A few years ago I visited a large manufacturing plant in Ohio, the president of which was quoted as saying that selling goods was 90 per cent of the business, and that the making of them was only 10 per cent. The guide stated that their Los Angeles representative had made something like $20,000 the previous year, and another who received $35,000 for the year. After telling the visitors that salesmanship represented 90 per cent of the endeavor, and construction only 10 per cent, he led them to the basement, and pointed out a lot of scrapped machines that had been sent back from Europe—$50,000 worth. When these were received the President of the Company said we will have to get engineers and workmen equal to the European engineers and workmen. They put inventors and engineers to work and soon produced machines that would do all that the European machines would do, and more, and then the salesmen in Europe were able to sell goods which would *stay sold*. Recently the President of this concern was convicted for overdoing salesmanship. It seems to me there is a tendency among some business people today to magnify salesmanship at the expense of engineering. Does this experience in Ohio show that salesmanship is 90% of the business? Do not engineers who make better things or more sufficient apparatus provide the fundamental reason for the sale of them?

Mr. John I. Rogers.—You say "Salesmen are born, not made" and I have been much interested in the talk about the education of the engineering salesmen. These large companies have a very interesting and extensive system of training salesmen which smaller concerns could not possibly have and therefore the smaller concerns have to train their salesmen along different lines, or take salesmen who have formerly worked for the larger companies, and thus get the benefit of their previous training. Most of the engineering salesmen that I have had experience with are very well educated, especially in the technical line of what they are selling. I think it is much easier to make an engineering salesman out of an engineer than it is to make an engineering salesman out of a plain salesman.

Where a great many companies are at fault is in the purchasing end. The salesmen seem to have been educated in the best possible way to explain to the

two things; either the complaints are very carefully kept from them or else they are, to say the least, stretching the truth.

The speaker has had a good many years' experience with the purchase and operation of mechanical appliances of all kinds and he has yet to find the perfect article, and he believes it is far better for the salesman to be truthful and state the weak points as well as the good ones, so that the customer will know what to look out for, than to try to make the customer believe that his article is perfect and fool proof and that it will never wear out or give trouble.

Of course, the trouble is not always reported and the article is often thrown out, particularly if it has been bought and paid for, without notifying the manufacturers as that often means more or less discussion without any satisfaction. In fact, the speaker has known cases in which concerns have advised that their apparatus was used by companies long after it was in the junk pile.

Only the other day I was looking up the question of purchasing a piece of apparatus and went to the factory to see it. I asked particularly what troubles would be expected with this apparatus, and was told of those as well as the

good points. The good points overbalanced the trouble, however, and that piece of apparatus was purchased, but we know about what trouble to provide for and trust that it will give satisfaction.

MR. R. GEO. WARD.—I cannot speak from the standpoint of the college salesman. I came to this country about ten years ago and landed in New York without practically any friends, and I always had it in my head that I could sell goods. I took a job at ten dollars a week, and I remember applying for a job as salesman, and in an interview with the General Manager of the Sales Department he said "What do you know in regard to the application of steam specialties in power plant equipment?" I said "I do not know anything about your business, but if you will accord me the privilege of going into your factory to see what I can do, and then send me out, I believe I can make some showing." So they did. Twenty-two men applied for that position, and in nine months they sent me down here as Manager of their Philadelphia Office.

A few weeks after arriving in Philadelphia I had an experience that I shall never forget. I had to go to see the Chief Engineer of a concern. This man was well known for the extensiveness of his vocabulary. He graduated from a university, and the more swearing he could do the better he liked it. I knew if I sent in my card I would not get an interview, so I followed my card very closely, and seeing the gentlemen was not engaged I walked in. The first thing he told me was to go to the hot place. But I leaned over his desk and said, instead of going to a place where they keep automatic stokers, I want to make a test to demonstrate that my goods are equal to what you are using, and if they are, I want an opportunity to get a contract for the goods that we want to sell. That man gave me my opportunity in Philadelphia.

I have worked hard on certain propositions, and I have often wondered why I could not sell to certain people. I have studied the men from every angle, and yet in certain cases I have not been able to sell. There may be various reasons for that. Our personality may not appeal to a prospective buyer, and, as Mr. Hess said, our thoughts may not run in the same channel.

I think I have learned something tonight as to what to do with the goods I have in mind for next week.

MR. H. V. SCHREIBER.—It is interesting to compare the methods of training salesmen used by the companies with which the first two speakers are connected. The first speaker laid special stress on the special detailed technical knowledge of his salesmen who handled a class of products the qualities and manufacture of which the salesmen must know thoroughly. The second indicated how a man could be trained in the principles of salesmanship; having the technical knowledge of the product as a part of his previous education, he needs to be taught the way to dispose of his product.

Much of the merit of the methods described by electric lighting and power companies is doubtless due to the long continued and now highly developed work of the National Electric Light Association. Co-operation in many problems of both manufacture and sales by companies naturally non-competent has proved of wonderful benefit and should be a good example to manufacturing companies in many lines where co-operation is possible along lines that may not seen practical at first.

there was a difference of opinion between the commercial men and the engineers, and it was not until the commercial men came into their own that proper progress was made in the electrical industry. The great efficiencies that are produced in central stations today are due to that fact. The question has been raised as to the desirability of the class work. It is surprising the number of good ideas that are brought out in the class and given to

the engineers, and which they make use of, and today they welcome the opportunity to meet with the commercial men. In our own Company we have an organization that is a branch of a very large national organization, where we get together monthly. Probably 50% of the membership of that organization get together monthly to discuss ways and means of doing things right. In addition to the main meeting there are three branch meetings, and they each evolve their problems. We in the main meeting then attempt to solve these minor problems.

In regard to the salesman. If he were to study with attention the four factors that have been read, and follow them through to the resolve to buy, probably he might secure that which we are trying to secure—the sale of the goods. That is not mere guessing ability in our case.

Mr. Trautwine has discussed, I think, the sting or the bite. It is true that people are being bitten today, and it is pitiable. It makes it more difficult for the honest salesman to sell his goods. It is singular, too, that the biting continues, and I think the biting in the salesman field will continue for some time to come, and I believe you men can help us to wipe out these difficulties.

Mr. Gibson reported for the special committee on water supply in the Club house, and recommended that new risers for the hot and cold water be installed in the front and back of the building with a laundry heater and reserve tank to relieve the present unsatisfactory conditions in the water supply. Appropriation not to exceed $350.00 was made to this Committee, which is to cooperate with the House Committee in the installation of these additions.

The Treasurer reported a list of members to be dropped, and he was authorised to strike from the rolls all those members delinquent for one year or more, The list comprises the following: C. K. Brown, Harold E. Brunner, W. I. Cheyney, L. P. Clark, W. L. Clayton, Charles J. Corr, John N. Costello, James E. Diamond, Charles L. Downs, Thomas M. Eynon, Hugh P. Fell, Richard B. Ferris, William H. Ford, J. Grier Foresman, Frank E. Hahn, Walter S. Hine, H. W. Huntsinger, A. M. Loudenslager, W. K. Mitchell, George K. Myers, David M. Niver, Harold S. Pierce, John A. Robb, Robert F. Runge, C. Carroll Sloan, F. F. Waechter.

Mr. Yarnall reported on the progress of the Engineering Co-operative Movement.

Communication from the Philadelphia Section of the Massachusetts Institute of Technology was referred to the Executive Committee of the Engineering Co-operative Movement, with power to act.

The question of renewing the first mortgage, which expires December 26, 1915, was referred to the Finance Committee.

A communication from the American Publicity Bureau was referred to the Publicity Committee.

The Finance Committee was requested to prepare a budget to be presented at the next meeting of the Board.

Regular Meeting, March 16, 1915

Present: President Ledoux, Directors Gibson, Hibbs, Wagner, Andrews Dauner, Dunlap, Bonine, Irish, Jones, and the Secretary.

The minutes of the Regular Meeting of February 16 were read and approved.

The Secretary reported the resignation of J. A. MacLennan, which was accepted as of December 31, 1914.

The Treasurer reported a net gain of $142.92 to March 1, as compared with a net gain of $17.55 for the same period of 1914.

Report of the Finance Committee was submitted and the various Committees were instructed to prepare a detailed budget to be presented to the Finance Committee at the earliest possible date.

Reports of the House, Membership, and Publication Committees were presented and approved.

The following Tellers and Alternate Tellers were appointed by the Board for the year 1915:

Tellers: John S. Ely, George W. Hyde, Joseph W. Silliman.

Alternates: H. P. Gant, Thomas M. Chance, Charles Elcock.

The Secretary announced the death, on January 16, 1915, of William Penn Evans. The Publication Committee was instructed to prepare a suitable memorial for publication in the Proceedings.

The following resolution was adopted, to be inserted
meeting and signed by each Director:

Resolved, that for the year beginning May, 1915, and
present Directors of the Club shall continue in office,
so that a majority of such Directors present at any
power of casting but one vote upon any question, wh
tive of an Affiliated Organization on the Board so

At the Annual Meeting in May, 1916, the whole present Board will retire from office and one or more Directors-at-large shall be elected to conform with Section 6 of the By-Laws. Should any one of the said Directors die, resign, or cease to be members of the Club during the said Club year, the vacancy so caused shall not be filled, but the remaining members of the Board shall continue to act as above provided for.

In addition to the resolution submitted by the Special Committee, the following recommendations were made and approved by the Board:

First, that no changes be made in the personnel of any of the standing Committees (Finance, Membership, House, Publication, and Meetings), except the Meetings Committee, and of this, the Chairman should remain, and the Chairman of the Publication Committee should remain. The places of the other members of this Committee should be filled in accordance with the new By-Laws.

Second, all other Committees should be asked for a report and discharged (Public Relations, By-Laws, and Increase of Membership).

The Philadelphia Section of the American Institute of Electrical Engineers, the Philadelphia Chapter of the American Society of Mechanical Engineers, and the Philadelphia Chapter of the Illuminating Engineering Society were elected to Affiliated Membership.

The application for Affiliated Membership in the Club of the American Society of Engineers, Architects, and Constructors was presented. It was moved and carried that the application be referred to the Membership Committee.

After considerable discussion, it was moved and carried that the present Meetings Committee be designated the Papers Committee, with the duties remaining the same, the Chairman of the Papers Committee to be the Chairman of the Meetings Committee, in accordance with the provisions of our new By-Laws.

Mr. Washington Devereux was appointed delegate to represent the Engineers' Club at the Convention of the National Fire Protection Association.

Mr. J. H. M. Andrews and Mr. Charles F. Mebus were appointed delegates to represent the Engineers' Club at the election of Trustees at Pennsylvania State College.

Communication was received from the Committee on Public Relations and the following resolution was ordered to be presented to the Club at its Regular Meeting on April 17:

WHEREAS, a movement is now on foot to form a comprehensive organization for the development of the commercial interests of Philadelphia, and

WHEREAS, the scattering of effort among a number of organizations having similar or nearly similar objects is detrimental to efficiency; therefore be it

Resolved, that the Engineers' Club of Philadelphia views with sympathy and satisfaction the movement looking to the co-operation of commercial interests of the city through the creation of a "greater Chamber of Commerce."

The application of the National Safety Council for the use of the meeting room was presented to the Board. It was moved and carried that the Secretary be instructed to reply to the application to the effect that the practical

ABSTRACT OF MINUTES OF THE CLUB

JOINT MEETING, JANUARY 16, 1915,

of the American Institute of Architects, Philadelphia Chapter, and the Engineers' Club of Philadelphia.

The meeting was called to order by Vice President Mebus at 8.30 P. M., with 127 members and visitors in attendance. After welcoming the Philadelphia Chapter of Architects, Mr. Mebus relinquished the chair to Mr. Percy L. Madeira, chairman of the Philadelphia Chapter, who introduced the speaker of the evening.

Mr. Walter H. Cook, Past President of the American Institute of Architects, presented a paper entitled, "The Present Tendencies of Development in American Architecture."

Mr. Grosvenor Atterbury, Secretary of the Russell Sage Foundation, presented a paper entitled, "Working Men's Homes."

Dr. Carol Aronovici, Messrs. Leffmann, Maignen, and Jones discussed the papers.

SPECIAL MEETING, JANUARY 19, 1915

The meeting was called to order by President Swaab, at 8.40 P. M., with 53 members and visitors in attendance.

Mr. W. A. Blonck presented the paper of the evening entitled, "European Boiler Room Practice and Boiler Efficiency Methods in U. S. A., with Reference to Electric Light and Power Plants."

37TH ANNUAL MEETING, FEBRUARY 6, 1915

The Meeting was called to order by President Swaab at 8.40 P. M. with 112 members and visitors in attendance.

Minutes of the joint meeting of the American Institute of Architects, Philadelphia Chapter, and the Engineers' Club held Saturday, January 16, 1915, were approved as printed in abstract.

Proposed amendments to the By-Laws were submitted signed by the following active menbers: D. Robert Yarnall, W. P. Taylor, Carl Hering, Fred C. Dunlap, W. Copeland Furber, Henry Hess, S. M. Swaab, Charles F. Mebus, H. L. McMillan, Manton E. Hibbs, B. A. Haldeman. The president announced that in accordance with the By-Laws these proposed amendments will be brought up for discussion and further amendment Saturday, March 6, 1915, and if accepted will then be formally acted upon Saturday, March 20, 1915.

Vice President Mebus then took the Chair and President Swaab presented the paper of the evening entitled "The Fundamental Elements Entering into the Makeup of the Modern City and a Plea for a Smaller City."

this movement by the Executive Committee has rejuvenated it, and we hope it will blossom into maturity in the very near future. The tendency of the times is towards conservation. Concentration and central control are necessary for efficiency and economic administration of all organizations, whether commercial or otherwise. The movement is therefore a natural concomitant of the heretofore existent conditions and is in keeping with the highest ideals and traditions of our times. It is my earnest desire that we may all live to see the accomplishment of this movement which cannot but make for our good.

"I wish to thank the officers of the Club for their intelligent and earnest support during the last year, during only a part of which I was allowed the high privilege of presiding over the Club, owing to a severe physical disability contracted prior to my election to the Presidency. I wish also to express my sincere thanks to the Club membership at large for their approval of the course steered by the Board, which, although it has been tortuous at times, has always made for the material advancement of the Club; and last but not least let me say that the loyalty, faithfulness, intelligence, and devotion to duty of the employees of the Club deserves and receives my heartiest commendation.

"I am privileged to introduce to you my successor in office, Mr. John W. Ledoux."

REGULAR MEETING, FEBRUARY 20, 1915

Meeting was called to order by President Ledoux at 8.30 P. M. with 117 members and visitors in attendance.

Secretary announced the election of H. S. Goodwin, Eberhard Henriksson, Arthur C. Toner, and W. W. Haughey to active membership.

Messrs. R. L. Gillispie, John Meyer, and Herbert W. Hess addressed the Club on "Training the Engineering Salesman."

Messrs. J. C. Trautwine, Jr., W. R. McLain, J. Frank Dechant, and H. V. Schreiber participated in the discussion.

BUSINESS MEETING, MARCH 6, 1915

Meeting was called to order by President Ledoux at 8.15 P. M. with 97 members and visitors in attendance.

The Amendments to the By-Laws were discussed, amended, and ordered sent to the members for ballot.

Mr. Oliver Randolph Parry presented the paper of the evening entitled "The Use of Reinforced Concrete and Hollow Tile in Dwelling House Construction."

Messrs. Swaab, Hibbs, and Boorman discussed the paper.

BUSINESS MEETING, MARCH 20, 1915

Meeting was called to order by President Ledoux at 8.35 P. M. with 81 members and visitors in attendance.

Mr. Howard W. Du Bois presented the paper of the evening entitled "Concentration of Ores by Oil" which was discussed by Messrs. Maignen, Hering, Cambe, Klotz, Chance, and Keith.

Following his paper, Mr. Du Bois showed some wonderful stereopticon views of Alaska.

The President read the report of the Tellers on the Amendments to the By-Laws, which showed that 74 legal ballots had been cast, 70 for and 4 against the amendments.

ST. GEORGE HENRY COOKE

The death of Captain St. George Henry Cooke removes from the Club rolls one of the most prominent and promising of its younger members and leaves to mourn his loss a large circle of friends to whom he had endeared himself.

St. George Henry Cooke, son of Rear Admiral George H. Cooke, U. S. N., retired, was born in Philadelphia, Penna., June 2, 1883. He was graduated with the degree of C. E. from Pennsylvania Military College, Chester, Pa., June 18, 1902, and immediately thereafter entered the employ of Roydhouse Arey and Co. He successfully supervised construction work for this firm in Philadelphia and Altoona until December, 1905, when he severed his connection to accept a position as Assistant Engineer in connection with the construction of the Tidewater Railway Co. Here he remained until January, 1908, when he opened an office in Chester, Pa., subsequently moving it to Philadelphia, where he continued to transact a consulting business until ill health forced his retirement from active pursuits.

A man of unusually promising professional attainments, he is best known to the Club membership for his connection with the successful military organization which represents the Club in the National Guard of Pennsylvania. On January 8, 1909, this organization, composed of Club members, was mustered into the service of the Commonwealth as Co. "B" Engineer Battalion, N. G. P., and Captain Cooke was unanimously chosen as its Commanding Officer. Military by instinct he threw himself with energy and enthusiasm into the work of organization and training. So marked was the success of his efforts that the Company soon took rank among the leading units in the State service and gained for its commanding officer the official approbation of the U. S. War Dept., as "an officer eminently fitted for command."

Elected to the Engineers' Club as a junior member, Feb. 20, 1904, he was transferred to Active membership Dec. 31, 1908, and served as Director from January, 1911, until March, 1913. Captain Cooke was also an Associate Member, American Society of Civil Engineers; American Society of Mechanical Engineers, and was a member of the Military Order of the Loyal Legion.

Suddenly stricken in the midst of his activities in July, 1912, he made a long and brave fight against the encroachments of disease. A short residence at Saranac Lake, N. Y., seemed to afford some relief and in December, 1914, he went to Fort Bayard, N. M., in hope of more permanent results. Here the Grim Reaper found him and on Jan. 12, 1915, he bravely surrendered all that young life might hold for him and passed "over the river to rest under the shade of the trees." Able, conscientious, lovable, he left an enduring organization which he builded and scores of friends who will remember him only with love and with regret.

His widow, Isabelle Dalmas Cooke, and three small children survive.

ANNUAL REPORT OF THE BOARD OF GOVERNORS FOR THE FISCAL YEAR 1914

January 12, 1915.

To the Members of the Engineers' Club of Philadelphia:

The Board of Governors herewith presents its report for the year ending December 31, 1914, as follows:

Thirteen stated, two special, and eight joint meetings of the Club were held at which the maximum attendance was 211 and the average 102. Eight regular and one special meeting of the Board of Governors were held.

The Summary of Membership on December 31, 1914, as compared with the Summary of December 31, 1913, is as follows:

	1913			1914		
Class	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Honorary....	1	1	2	2	2	4
Active.......	340	113	453	331	109	440
Associate....	63	10	73	54	14	68
Junior.......	54	11	65	46	10	56
	458	135	593	433	135	568

Twenty Active, four Associate, eleven Junior, and one Honorary Member were elected. Eight Junior Members were transferred to the Active grade, one Junior to the Associate grade, and one Active to the Honorary grade. Four Active Members died. Thirty-six Active, ten Associate, and eleven Junior Members resigned. One Active Member was dropped from the rolls. One Active Member was reinstated to membership.

The record of deaths is:

W. B. Riegner, Active Member, died January 19, 1914.
Charles W. Close, Active Member, died February 7, 1914.
A. E. Harvey, Jr., Active Member, died February .., 1914.
George L. Miller, Active Member, died August 12, 1914.

During the year our special committee on Engineering Co-operation has been actively engaged in the broad movement for bringing about an affiliation of engineering activities in Philadelphia.

The work of the Executive Committee of the Engineering Co-operative Movement is represented by the attached proposed Charter and By-Laws of the Engineers' Society of Philadelphia. The individuals of our Committee are

January 17.—"Recent Locomotive Development," George R. Henderson.

February 3.—"Mineral Resources of British Columbia and Alberta," Howard W. DuBois.

February 7.—Annual Address, President W. P. Taylor.

February 21.—"Radio-activity with Special Reference to Radium," Arthur W. Goodspeed.

March 7.—"The Rebuilding of Forty Miles of the Lackawanna Main Line," G. J. Ray.

March 21.—"A Hydro-Electric Development on the Tallulah River, Georgia," John Birkinbine.

April 4.—"The Foundations of the Woolworth Building," Edward S. Jarrett. "Difficulties in the Construction of the Woolworth Building," G. F. Shaffer.

April 18.—"Report on Public Service Properties," E. P. Roberts.
May 2.—"Evolution of the Modern Battleship," W. A. Dobson.
May 16.—"Electrometallurgy," Joseph W. Richards.
June 6.—"The Power Problem in the Lehigh District," Hermann V. Schreiber. "An Analysis of Electric Drive in Cement Mills," Thomas H. Arnold.
September 19.—"Modern Road Building Here and Abroad," T. Hugh Boorman.
October 3.—"The Water Supply of Ancient Jerusalem," Henry Leffmann.
October 17.—"Air Conditioning," J. Irvine Lyle.
November 7.—"Physical Photometry," Herbert E. Ives.
November 21.—"Bituminous Coals. Predetermination of Their Clinkering Action by Laboratory Tests," F. C. Hubley.
December 5.—"The Bureau of Standards and Its Relation to the Industries," S. W. Stratton.
December 19.—"Mercury Turbine," William L. R. Emmett.

FINANCIAL REPORT FOR THE YEAR 1914

Statement of Assets and Liabilities as of December 31, 1914

ASSETS

Cash—Colonial Trust Co.—Active Account	$ 609.13	
Colonial Trust Co.—Interest Account	1,526.11	
Petty Cash Fund	200.00	
In Office	68.57	
		$2,403.81
Accounts Receivable		3,610.76
*Building Fund Notes, special fund	3,250.00	
*Second Mortgage Bonds, special fund	200.00	
		3,450.00
*Sinking Fund for Redemption of Second Mortgage Bonds:		
Regular Account	$ 38.50	
Interest Account, special fund	274.10	
Principal Account, special fund	383.16	
		695.76
Inventory of Supplies on Hand		
Wines and Liquors	$267.22	
Restaurant Provisions	124.17	
Cigars	191.29	
House Supplies	28.87	
	611.55	
Fuel	32.75	
		644.30
Insurance		
Perpetual on Club House	$1,603.80	
Employer's Liability	14.58	
		1,618.38

Suspense Account, Uncollectable Accounts	202.39		
		949.46	
Surplus as of December 31, 1914			13,229.22
			$98,212.24

STATEMENT OF INCOME AND EXPENSE FOR THE YEAR ENDING DECEMBER 31, 1914

INCOME

Dues—Net	$15,541.07	
Initiation Fees	515.00	
		$16,056.07

Publications

Advertising—Directory	$335.00	
Advertising—Proceedings	571.80	
Sales—Proceedings	57.05	
		963.85

Miscellaneous

Badge Sales		$9.50	
Interest on Deposits, Active Account	$45.48		
Interest on Sinking Funds	22.88		
		68.36	
Telephone Receipts		150.24	
			288.10

Club House Business

Billiard and Pool Sales	$197.87	
Cigar Sales	2,297.11	
Lodging	2,897.70	
Rent of Meeting Room	618.79	
Restaurant Sales	7,546.26	
Restaurant Sales, Meals	2,232.00	
Wine Sales	995.89	
		16,166.83
Total Income		$34,033.64

EXPENSES

Salaries and Wages

Manager		$2,100.00	
House, Salaries and Wages	$2,861.01		
House, Meals of Employees	720.00		
		3,581.01	
Office, Salaries	$1,705.71		
Office Meals of Employees	432.00		
		2,137.71	
Restaurant, Salaries and Wages	2,972.39		
Restaurant, Meals of Employees	1,080.00		
		4,052.39	
			11,871.11

Expense

House Expense	$1,109.57	
Office Expense	450.49	
Directors' Expense	24.15	
Library Expense	103.85	
		1,688.06

Publications

Directory Publishing	$ 314.71	
Proceedings Publishing	1,012.71	
		1,327.42

Miscellaneous

Badge Purchases		$ 9.50	
By-Laws Revision		36.90	
Club Luncheons		400.00	
Entertainment Committee, New Year's Day	$ 3.00		

Cigar Purchases		1,851.91		
Wine Purchases		698.26		
			2,556.72	
Restaurant Expenses		797.17		
Restaurant Provision Purchases		7,503.81		
			8,300.98	
Inventory, Dec. 31, 1914				
Cigars	$191.29			
Restaurant Supplies	124.17			
House Supplies	28.87			
Wines and Liquors	267.22			
		611.55		
Inventory, January 1, 1914				
Cigars	$239 32			
Restaurant Provisions	100.15			
House Supplies	62 93			
Wines and Liquors	274.19			
		676.59		
Add Decrease in Inventory			65.04	
Expense of Club House Business				10,922.[illegible]
Total Expenses				$34,780.[illegible]

Net Loss for 1914	747.07
	$34,033.64

Respectfully submitted,

J. R. BAILEY, *Treasurer.*

Audited and found correct:
VOLLUM, FERNLEY, VOLLUM & RORER,
Certified Public Accountants.

The following is the report of the Trustees of the Bond Redemption Fund:

SEVENTH ANNUAL REPORT OF THE TRUSTEES OF THE BOND REDEMPTION FUND THE ENGINEERS' CLUB OF PHILADELPHIA

BEING A STATEMENT OF BUSINESS FOR THE YEAR 1914

To the President and Board of Governors of the Engineers' Club of Philadelphia:
The Trustees of the Bond Redemption Fund present the following state of business since last report:

Receipts

1914			
January 1,	Balance on Hand	$312.26	
	Coupons Cashed	10.00	
February 5,	Interest on Note	162.50	
March 5,	Share of Surplus	188.12	
December 31,	Interest on Deposit	22.88	
			$695.76

Expenditures (None)

Balance, January 1, 1915	$695.76

The Trustees hold bonds Nos. 51 and 52 for $100 each; also note payable by the Club for $3250.

The other funds are on deposit at the Western Saving Fund Society of Philadelphia.

HENRY LEFFMANN,
EDWIN F. SMITH,
EDGAR MARBURG,
Trustees.

Respectfully submitted,

THE BOARD OF GOVERNORS,
S. M. SWAAB, *President,*
H. L. MCMILLAN, *Secretary.*

get away from corrosion, due to possible electrolytic action, between the weld and the original material.

Mr. E. M. Nichols: How thick plates can you handle? As Mr. Quimby asks, suppose you wanted to put two angles on the bottom of each web plate.

Mr. Bryan: The whole proposition depends upon the size of your welding machine—you are referring now to spot welding, I believe. Probably ⅞″ or 1″ would be the thickest that could be welded without a very big machine. It would take currents running into the thousands of amperes.

Mr. Nichols: Does the surface of those metals have to be prepared?

Mr. Bryan: For spot welding no special preparation is necessary beyond cleaning off the scale so as to leave the metal clean. In arc welding you can clean the work as they do in steam boiler work, by using a sand blast, but on work on castings the carbon electrode could be used to melt the surface so that sand and other impurities will run off, leaving clean metal. It is one of the essentials of arc welding to see that you have clean bright metal, and that you have no dirt or scale to be covered up in the weld.

Mr. Swaab then introduced Mr. H. F. Sanville, Chairman of the Philadelphia Section of the American Institute of Electrical Engineers, who assumed the chair and introduced the speaker of the evening, Mr. J. H. Bryan, of the Westinghouse Electric Co., of Pittsburgh, who presented a paper entitled, "Electric Welding," which was discussed by Messrs. Hartley, Quimby, Parsons, Nichols, Lewis, Chance and others.

Mr. John C. Trautwine, Jr., announced the death of Mr. John Birkinbine and gave a brief outline of Mr. Birkinbine's engineering career. Mr. Sanville announced that the annual banquet of the Philadelphia Section of American Institute Electrical Engineers would be held on Monday, June 14, 1915, at the Hotel Walton. .

be far better for both the engineer
learns that in civic affairs the en
servant of the people, capable of tak

The implication of the public offi
engineer could not be found with
serve on the Interstate Commerce
general support today, for most peo
hieroglyphic plans according to my
apart. His language is that blue p
finds expression before the public in
mate things.

As Berton Braley says of the
illustrate his talkativeness.

"When you need to dam a rive
Or to tunnel underneath it i
Or to bore an' blast a subway t
Or to blow aside a mountai
Why, you call on Leather Legg
An' then comes 'round an' a

Our position with reference to
John Alden courting Priscilla for
ourselves. And let us learn to sp
are at issue with such clarity and vigor that in the trial of a case before the jury of public opinion we will get an unanimous verdict. We can.

Our training and habits have not endowed us with eloquent tongues, although the ability to talk well will be added when the awakening spirit impels us to reach up to our opportunities. But a channel by which our story can be favorably told the public lies within easy reach.

Before showing on the screen what use has been made of the public print by the Cleveland Engineering Society and other engineering societies, let us discuss a few of the principles of publicity learned from the experience of several years.

News is a commodity handled by newspapers at a profit. From the standpoint of collecting news, it falls roughly into two classes, that which is gathered by the ordinary reporter or sub-editor at a considerable cost to the paper, and that which is offered gratis. The latter is highly competitive in itself in the cosmopolitan paper for the quantity offered is always in excess of space available.

The editors at the head of the
railroad, finance, marine, Sunday,
vary somewhat with each paper. F
on one paper was also movie editor,
wrote Sunday copy on minor theatri
of the several departments may b
accordingly. To illustrate, the rai
the Monday column must be filled.
do two days' work for Sunday and
for Monday will be invariably welc

When we started publicity worl
editor of one of the papers who
learned by going to the editor befo
only was his viewpoint obtained, bu
tral idea the copy was in a way to
competition.

When one article is handed in it i
or two to submit for opinion and th
a busy editor, or the chagrin of an

Study the style of the papers.
clip a few articles that seem espec
him while he prepares his copy un
first sentence or "lead" to attract attention and guide the reader into the story. Particularly in advance notices aim to answer the questions what, when, where, in the first sentence. Writing of headlines may best be left to the practiced newspaper man.

It would be much better to have nothing in the paper because of inability to prepare copy suitably than to have it refused. Lots of material is offered to the papers in form unsuitable for publication and, unless it possesses unusual news value, it goes into the waste-basket.

All copy should be typewritten and clear for time is a vital element in getting out a paper

To summarize, the successful preparation and placing of copy depends upon three things (1) news merit, (2) acquaintance with the editorial staff, (3) an understanding of the problems of newspaper making.

Now to find the man with a "nose for news." The ability to pen expressions that fit the average mind will come with practice and a study of psychology, just as the ability to design comes with practice

"U. S. Engineer Speaks Friday." this notice, the efforts of the Publi making the one at Epworth Memo success. We had notices posted o civic organizations and had announ We were gratified to see an atten especially inclement Sunday night.

"Engineers to See Pittsburgh Pla able custom of visiting back and f engineering societies of our section ing Society of Pittsburgh, Buffalo Toledo. The Detroit engineers o visit of last Spring.

I am inclined to place greater val ship part of these programs than o from visiting plants in other cities, boat are effective in getting memb out of which grows a common inter

The picture in the upper right ha notice of a popular lecture in East F. Creighton, Consulting Engineer (When we gave a duplicate of this picture to one of the papers, the city editor said it wouldn't justify reproduction. He said it was too black. When we showed the picture to the competing paper, we mentioned diplomatically that the editor of the other paper was afraid there wasn't enough contrast. The editor being addressed said, "Let us try it." The graphicness of the notice without the picture needs no comment.

On the right hand of the screen "Yale Summons Local Engineer" is a notice that one of our distinguished members was to give his lecture on "Engineering of Men" at Yale. Below that is an item informing the public that former Senator Burton has given his library of river and harbor literature to the local society. Next is an item telling of an event in our chess club when seventeen of its members were pitted at one time against a well known champion. At the bottom of this column, "Cable Long Used Bears 300 Tons," is an account sent to us by one of our advertisers in the Journal. It is a legitimate news item and good publicity for our advertisers and properly falls in the scope of our Publicity Committee's work.

"Bridge Foundations a Mighty Problem" properly may be classified as service to the community. The building of the foundations of a great high-level bridge, the main artery between two parts of the city, gave rise to a lively controversy as to their safety. The public had a right to know the truth. The county bridge engineer was asked to read a paper before the society describing the foundations, his paper was abstracted with technicalities omitted or so worded as to be understood by the reader of average education, and published in one of the papers on the Sunday following the meeting.

"Producer Gas to Eliminate Smoke and Save Fuel." Here are shown advance notice of the meeting and an abstract of Dr. Fernald's paper as it appeared on the Sunday following the meeting. Dr. Fernald was pilot of the Cleveland Engineering Society when its course was changed from a jack-in-the-box mutual admiration society to the wide-awake civic and professional organization we have to-day.

Fig. 7. "Local Men Will be Prominent in A. R. E. A. Meeting" and most of the other clippings in the upper left quarter of the screen appeared in the section of our papers devoted to railroads. The longest article is signed by the railroad editor, and the text is verbatim as we prepared it. "Railroad Engineers Conclude Convention," was a telegraphic report sent from Chicago, press rates collect, to the Cleveland papers after one of the railroad editors had suggested that we do it.

"May be Chief Engineer of Alaska Railroads." When Hunter McDonald, then President of the A. S. C. E., was being mentioned as possible head of the construction forces for the Government's Alaskan railroad, an excellent "news peg" was at hand on which to hang quite a story about the A. R. E. A. and A. S. C. E.

"Favors Unit Plan of Concrete Work." Here again are shown advance notices appearing on Monday preceding the meeting and a write-up of the lecture appearing on the Sunday following. The section of the Sunday paper in which this story appeared went to press on Friday night. In this instance copy was handled by the real estate editor who was also movie editor, although the dutie either job would keep one man comfortably busy. Copy, pres recent development in building construction eased the labor real estate editor and was given a hearty welcome by him.

"Weather Prophet's

"Weather Mixer Joins Enginee
forecaster took up his work in C
the Engineering Society. It wa
and his lecture on the "U. S. Wea
be given some publicity, introduci
land is in a district subject to so m
that the lot of the weather man is
of our worthy citizens would gree

The two clippings to the upper
notices. When we came to write
matter, we got down our cyclope
ing things, one of which was that a Clevelander while in Congress had a hand in the formation of the Weather Bureau. This, and several other interesting points, were ancient history, unless there could be found a "news peg" to hang them on, that is, to justify them. The new weather man and his lecture was the peg.

Fig. 8. "Engineering as a Life Work." Early in our publicity work there was published in one of the local papers a letter from a young man to the editor asking what the opportunities are in civil and mechanical engineering. The editor printed below the letter a request that engineers of each of these branches answer the question Of course, we are amused that anyone should expect the editor of a daily paper to answer the question, but the asking indicates at once the opportunity to perform public service through the medium of the daily papers

Here was an opportunity for the Publicity Committee. It accordingly asked the President of the Society to prepare an article in answer to the question to be offered to the editor of one of our papers. The editor liked the idea so well that he called for more and the series grew until there were fourteen articles. These articles with a few on the branches not treated in the Cleveland series have just appeared in book form with the title, "Engineering as a Career."

In any local engineering society there are men pre-eminently qualified to tell the young man what the opportunities are in the engineering profession and what is required in the way of training to succeed. Thousands of youths, their guardians and parents would eagerly welcome such advice, but they don't know how or where to get it. We are of the opinion that such a series as was run in Cleveland could be written in your society and that the papers would gladly

share in the opportunity to place such dependable information before the community.

There are several ways that may be used by engineers to educate the public besides the public press where an unsympathetic editor may inhibit our efforts. The Engineers' Society of Pennsylvania has conducted Industrial Welfare and Efficiency Conferences to the evident satisfaction of all participants.

As soon as time permits we plan in Cleveland to enlist a few of our younger engineers to give illustrated lectures on engineering subjects before small gatherings in churches, schools, libraries and the like. It is hoped that a sympathetic understanding of engineering knowledge and skill can be brought about more quickly by a personal contact of this sort. In addition, the speakers will gradually acquire by practice that facility of expressing on their feet which is necessary in order that we may argue on equal footing subjects in dispute before legislative bodies or large gatherings of citizens.

It is evident that the first missionary work must be done among engineers and that the measure of our progress in civic activities will be determined largely by our working together not only in communities but everywhere. In a word, Engineering Co-operation.

The experience which has been gained in one society should not only be the common property of all, but the peculiar conditions existing in each place should be interpreted so that general principles may be formulated. For instance, in Philadelphia the local sections of national societies are affiliated with the local society. In Detroit the quarters of the Engineering Society are rented to local sections, but coordination of effort is still to be worked out. In Cleveland the formation of sections of the national societies does not come about because it is felt that the local society so well fills the field that there is little need for the local section. Here are suggested the large questions:

Can the interests of the national societies be best forwarded by having local sections in affiliation with or separate from the local society; and, on the part of the local societies, do local sections of the national societies tend to strengthen or disintegrate the local organization? I incline to the opinion that interest in the local society is the parent of prosperity in the national organization.

It seems apparent that the interests of all engineers and techni men have so many points in common—dovetail, as it were—th any community there should be one home for all and that alon

tain lines all shoulders should
of the community and the eng

It can be truthfully said th
the constructive form favorab
cause the engineer has not tal
To what extent should we en
enter actively in political camp
erly set nor are the actors tr
debate. But in matters of p
ready to listen to what engi
Mayor would, I venture, not th
zens where engineering princi
selecting a due proportion of
nominations by the Board of
City Plan Commission is heade

Licensing of engineers by S
by engineers as well as by the p
tion in a broad-minded and unselfish way.

DISCUSSION

Mr J C. Trautwine, Jr (assuming the chair): Gentlemen, one of the unfailing cures for insomnia is to have the Speaker read his paper from his notes, and I regret to say that my faith in this cure has been shaken this evening Not only have I missed the refreshment from the evening nap to which I always look forward confidently but I am afraid that I am as wide awake as ever I shall certainly hope to enjoy the discussion which I have no doubt will be voluminous

Professor R. H. Fernald Having been connected with the Cleveland Engineering Society for many years, I naturally feel a very keen interest in the paper of the evening. Mr Drayer has not made it clear, I think, that he personally is really the backbone of the publicity work of the Cleveland Engineering Society, having been responsible for practically all the material that we have seen on the screen to-night. The Cleveland Engineering Society and engineering societies as a whole owe a great deal to Mr. Drayer for what he has accomplished in this direction.

An incidental illustration of the wide field which has been covered by the publicity work of the Cleveland Engineering Society is shown by the fact that only last night I happened to pick up a paper that comes to my

pass, and I think the speake
how to do it, and has let a lit

My experience with repo
hope there is no newspaper
who have not had the traini
ters, that qualifies them to p
reporters at the meetings he
Social Science, and out of a
only one or two who seem to
others putting in their time
and other things on their no
is reported the report is no
erroneously reported.

I contrasted the methods
Washington. Some time ago
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porters can handle it. I think if we should take some of the suggestions from the speaker of the evening that it will be of great help to us in our publicity campaigns.

Mr. Trautwine: I think that Mr. Furber is quite right—that the thing that stood out most pre-eminently to us here at The Engineers' Club was the startling contrast between Cleveland and Philadelphia in respect to the matter to which the speaker referred. I have the honor to be a member of the Public Relations Committee of this Club, and I regret to say that we have done very little I am at least partly responsible for what it has not done When we have had meetings and have discussed matters relating to the public affairs we have met with the caution that we must be careful not to interfere with politics—we would be pulling somebody's chestnuts out of the fire.

Mr Morris L. Cooke: I was not fortunate enough to be here in time to hear Mr. Drayer I am happy to say that I am fairly familiar with some of the things he has done, and I consider it not only an honor to the Club but a real service to Philadelphia to have Mr. Drayer come here and bring this gospel. Even though I had to spend a part of the evening elsewhere, I felt that I must get here before the meeting was over.

In studying the things that Mr. Drayer has been doing in Cleveland, we must recognize the fact that news has a technical quality, because

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peach baskets in use. We have
have taken their place.

We tried the experiment in parts of the city of putting one galvanized can on a block, and it was remarkable to see how first the next door neighbor and then the next followed suit. We have had some cases where all the housekeepers in an entire block secured the tin receptacles because it had become a question of social standing. The housekeeper says, "Mrs. So-and-So has a tin can, and if she has one we have to have one," and if one householder puts a top on, then the rest of the tops come.

In some instances we have made moves that we knew beforehand were going to get us in trouble, changes which we knew would bring down on us correspondence and kicks of one kind or another. By giving two or three months' notice, however, and by putting a little interesting statement in the newspapers that such a thing was going to be done, and following it up with letters to the Business Men's Associations and to a few women who were active in such matters, the blow was softened, and, as the expression goes, we have "gotten away with it."

Now street cleaning is only one of a great number of such problems. Any large public improvement can be pushed ahead if you can think of some scheme by which you can visualize it to the people. The best example of that kind that I know of is the main sewer, on which Philadelphia has been working for fifteen years, draining the low section at Broad and Allegheny Avenue. The city was given appropriations every year of $15,000, $20,000—I think the last was $40,000 But we needed $200,000 or $300,000 to finish it, and when the Business Men's Association came to me and asked me whether there was something that could be done I frankly told them that the best we could expect would be $40,000.

As luck would have it, there was present a little German baker woman; she was only about five feet high, with a shawl on and no hat. After his Honor, the Mayor, had listened to the citizens' eloquent appeals for the sewer, this little short baker woman told a painful story of how she lost a barrel of flour every time it rained. This woman's plight had the reporters almost in tears, and her story appeared on the front pages of the afternoon papers The result was that the people simply tumbled over themselves to give us that $200,000 and when we found that that

Dr. H. M. Chance: I have l
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of the city would not care to [illegible] is ripe to take action One matter I have in mind that must come before the public shortly is sewage disposal If sewage disposal is a good thing in Philadelphia, the Engineers' Club might do a great deal to place the matter before the public in an intelligent way, to educate the public so that it would be prepared to endorse the project when it became necessary to take action

Mr. R. H. Fernald Apparently my former remarks were not quite clear. I happened to be a member of the Executive Committee at the time the Cleveland Engineering Society was asked to investigate the typhoid fever scare and to make recommendations to the Mayor, and I believe we shirked nothing. Naturally we did not say to the Mayor, "Will you please hire one of us"? We were asked to advise regarding the best method of procedure and we recommended that he secure the best possible experts. One of the men selected was already in Cleveland, the second man, it happened, came from outside but was selected because of his recognized standing in this particular field. Our recommendation did not suggest that the Mayor ignore Cleveland engineers and go outside for experts but we felt it important that the city secure men generally recognized as best qualified for this particular problem. We were not asked to name specifically members of our organization and we felt that in making our recommendation to the Mayor we were rendering the

with matters of public interest! free to print what is said at ou ever interesting to the general p symptom of a connection with matter, the Editors are shy.

Twice lately, one of the Phila speaker in search of information timely interest. The reporters or other it did not appear. It m who perhaps thought that the "some one" and that the adverti

The line between what is "new vertising is elastic, and the "c which are purely advertising m clusive.

Give the newspapers plenty of copy, even though it ran the risk of falling into the waste-paper basket.

Mr. Trautwine: They seem to have avoided that in Cleveland. Mr. Drayer, will you close the discussion by telling us how they did it?

Mr. W. C. Furber: May I say something about the activity of the architects among the local Chapter along these lines in Philadelphia? The local Chapter, as you probably know, have undertaken and did undertake the work of Congress Hall and have worked on the reconstruction of Independence Square. All that work has been done along the lines as Mr. Drayer suggests.

A member: I want to add a word if I may, to what Mr. Furber said about reporters. Some years ago I was in Cleveland at the convention there and I noticed such experts as Mr. Edwin M Bassett and Mr. W. S. Purdy, of New York, got on the first column of the front page. Some time after we had Mr. Bassett here in Philadelphia, and I myself wrote to the newspapers asking if they would give the proper publicity to what he said, as it had eminent news value for Philadelphia We got a little squib on one of the inside pages and some months afterward my name came up before the newspaper editors before the reporters and I was criticised because in my asking for publicity of Mr Bassett I asked that "competent" reporters be sent to handle the meeting, and that letter of mine was passed around among the reporters and they evidently all remembered my name and evidently took it as a slight upon themselves, which was certainly a case of the shoe fitting the man that took it, when I asked that competent reporters be sent to handle Mr Bassett's remarks. So that my observation of the Philadelphia reporters is that there are very few of them that are stenographers and that doesn't seem to be true of other cities In Washington the men that I spoke of were newspaper reporters. In Chicago they were newspaper reporters and they were competent stenographers. But at the Mayor's convention here, which was one of the most important conventions, I was right behind the reporters' table, and

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THE ENGINE

Hon. JOH
Judge of (

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construction of buildings of
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engineer in designing and supervising the work; but in case of disputes between parties or in case of accident to those engaged in the work, it is absolutely necessary, at times, to have the trained engineer go upon the witness stand, not only to testify to facts, like the ordinary witness, but also to sometimes give his opinion based upon his experience and training in his chosen profession.

King David once said, "All men are liars." To the inexperienced person who sits in a courtroom and listens to the numerous contradictions between witnesses to the same transaction, the truth of King David's statement seems obvious. As one becomes more familiar with the mental processes of the witnesses, however, it would seem that cases of conscious and wilful perjury are quite rare, but that, as a whole, human testimony, even when intended to be honest, is inaccurate and is frequently worth very little.

The great historian, Freeman, has said: "I am beginning to think that there is not, and never was, any such thing as truth in the world. At least I don't believe that any two people ever give exactly the same account of anything, even when they have seen it with their

own eyes, except when they copy from one another." It was no less a person than Goethe who declared that "the only form of truth is poetry."

King David's denunciation still adheres, by common consent of lawyers, judges and laymen, to the expert witnesses. That the reputation of this class of witnesses for truth and veracity is shockingly bad, is a matter in which there is surprising unanimity.

Mr. Taylor, in his work on evidence (Sec. 58) speaking of them, says:

"Their judgments become so warped by regarding the subject in one point of view that even when conscientiously disposed they are incapable of expressing a candid opinion. Being zealous partisans, their belief becomes synonymous with faith as defined by the apostle, and it is too often but 'the substance of things hoped for, the evidence of things not seen.' "

Mr. Redfield, in his work on "Wills" (Vol. 1, page 103), says:

"Medical experts are beginning to be regarded much in the light of hired advocates, and their testimony is nothing more than a studied argument in favor of the side for which they have been called."

These opinions might be multiplied without number.

Many of the objections to expert testimony are based upon its inherent weakness. They are directed toward defects which exist in all human testimony, and are inseparable from any system of trying differences between man and man, but which afford no sufficient reason for excluding such testimony.

In any litigation the probable truth is all that courts can hope to attain, whether with or without the aid of expert testimony. Absolute justice the courts do not profess to administer; they must and do rely upon human agencies, with all their limitations and imperfections, to arrive at the probable truth; and if expert testimony is more unsatisfactory than others, allowance must be made for the nature of the subject matter and its inherent weakness, and accept it as less harmful to society than the failure of justice which would ensue without it.

The highest and best form of evidence is supposed to be that given by a witness who speaks as to something that he has actually seen heard or observed. But the capacity for observation, for receiv and noting impression, is, in the average person, so limited th can observe and record a part only of incidents hurriedly trans

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In the domain of expert testimony the inherent difficulties are much greater. Expert witnesses do not speak facts or of their personal knowledge, but give opinions based upon facts to which others testify; it is not surprising, therefore, that their testimony is, as a rule, much less reliable. Expert witnesses are not only subject to the same mental limitations as are laymen, but the subjects as to which they are usually called to testify are more subtle, more difficult of ready comprehension, more complex, more speculative. They are also often called as to matters with respect to which the higher and more reliable forms of testimony cannot be obtained.

Some of the criticism of the expert is due also to the popular misconception that there is always a right and a wrong side to every legal controversy. The truth is that there is seldom a plainly right and a plainly wrong side to a difference of opinion. Persons seldom carry their differences to the stage of litigation where one is plainly right, and the other plainly wrong. But there are a large number of complications arising in the course of business, and in the relations of life which are due to a failure to settle difinitely in advance the exact terms of an agreement—cases in which some important consideration is left open for future adjustment or is not taken into the account; cases in which from one cause or another persons doing business together, fail to understand each other in the same

sense, and the result is a final disagreement as to their respective rights. And here begins the need of the law and the lawyer.

None the less, the boast of the English law is, and has been, that there is no right without a remedy, no wrong without a process to redress it; the law is exceedingly reluctant to say to any supplicant that it has no means whereby the truth or right of an alleged grievance can be got at, and a just decision made. A familiar example will make clear the difficulties in this respect with which imperfect human tribunals are called on to deal.

A husband and his wife, or a father and his child, may, and often are, lost in a shipwreck, or killed in a collision. And it becomes necessary in the distribution of property to determine which died first; if the husband or the father, the estate may go to one set of persons, if the wife, or the child, then to another set of persons. If direct evidence on the subject can be obtained, it has always been given the preference. But, in the early days of English law, rather than admit themselves to be helpless in the face of an entire failure of such proof, the courts resorted to presumptions based on the assumed ability of one person, rather than of another, to resist death; and it is only within comparatively recent years that the courts have been forced to admit that the situation thus created is insoluble by legal means, and that as courts can only grant relief after proof of the necessary facts with legal certainty, the litigant who asks the aid of a court must be denied it, unless he comes armed with the requisite proof. The result often is that the person in possession is permitted to retain the property regardless of what may be the exact rights of the parties.

But the law abhors a result of this sort, and to avoid it in other similar situations, has permitted the use of opinion and expert testimony to what, at times, may seem an unreasonable extent.

In considering the various objections to expert testimony and the suggested remedies, it will aid one in clear thinking to recall just what expert testimony is and when it may be used. "An expert is one instructed by experience, and to become one requires a course of previous habit and practice or of study so as to be familiar with the subject."

Such witnesses may be called whenever the matter of inquiry is such that persons without experience are not likely to be able to form a correct judgment upon it, for the reason that the subjec

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this sort of testimony is a necessity, for the plain reason that jurymen are selected from the average of mankind and are not required to have any special skill or knowledge in the branch of art, science or trade drawn in question on the trial. Indeed, though trial by jury were abolished, and a bench of Judges were substituted, the necessity for expert testimony would be very slightly diminished, because the questions arising in litigation are so diversified that the most learned Judges would be quite as helpless as an ordinary juryman. Unless, therefore, one is ready to admit that the truth should not be sought from those best able to give it, and that issues of "great pith and moment" shall be decided without receiving all the light reasonably obtainable, no branch of expert testimony can, it seems to me, be safely limited to a scope narrower than that hitherto recognized as legitimate.

The critics of expert testimony seem to act on the belief that the only experts called as witnesses are physicians, surgeons, alienists, toxicologists and specialists in handwriting. Most criticisms, at least, are made in connection with these classes of witnesses. Critics do not take into account the great army of experts who are daily before the courts of the country testifying as to matters of civil engineering, electricity, mechanics, architecture and building, commerce, trade, navigation, stock breeding, manufacturing, insurance, printing, publishing, binding, mining and a dozen other occupations and callings which, at least, in some of their features, involve matters beyond the scope of the ordinary knowledge of the ordinary man.

There are many grounds for criticising the expert and his testimony. Some of these attacks are just, some, I suppose, are unjust.

Many who discuss the question begin by attempting to discredit all, worthy and unworthy alike, who testify as experts. This is just the state of mind desired by the fakir experts and their employers who seek to defeat justice through such testimony, and is a sure means of making it more difficult to get the best men to testify as experts.

Practical improvement certainly is possible, but it is not to be brought about by indiscriminate criticism but by criticism and correction of the procedure that makes possible the prostitution of expert testimony.

The abuses of expert testimony are well known, but some of the causes that have led to the abuse are not always so freely discussed, especially by those who debase expert testimony in order to win law suits. The "contingent fee" has no doubt been a potent means of debasing expert testimony. When an attorney becomes in effect a partner in a controversy, his zeal in gathering testimony is naturally stimulated, and if his success depends mainly upon expert testimony he is inclined to look till he finds just the kind he wants.

The technical expert witness is beset with the same temptation that surrounds every lawyer, that is, the opportunity for hire to defeat the ends of justice. Unfortunately, there are those in both fields for whom the temptation is too strong.

The corrupt expert witness is a willing tool in the hands of a willing attorney. One of these parties is often overlooked and strange to say, the most violent criticism of experts usually comes from those who themselves have prostituted the subject. The zealous attorney may succeed in befogging the subject by the harmful errors of the inexperienced and uninformed, who are urged to undertake to do what no man can perform, or by the use of the witness without conscience who is simply a perjurer for hire.

Zealous advocates can tease, flatter, threaten and bribe specialists to assist in trying to show, not always perhaps that black is white, but that black is at least a light gray.

Much of the discredit that has been brought upon expert testimony has come from members of the medical profession who have been used in this way by zealous attorneys simply as tools to perpetrate fraud. In order to illustrate some of my remarks and to

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not be possible to overcome That well established legal principle which allows a man to call his own witnesses will probably make it impossible to keep liars out of courtrooms as witnesses, but it certainly is possible by official designation and judicial recognition to so enforce the testimony of worthy and competent men that the testimony of opposing corrupt or mistaken witnesses is rendered less harmful.

It has been suggested that the hypothetical question should be suppressed or not permitted.

Another eminent authority says he would abolish altogether the use of the hypothetical question on direct-examination. He would require the expert to be present in court during the trial, listen to all the evidence, and at the end of the trial, go on the witness stand, "and give his opinion based upon all the evidence in the case just as it was presented." Then, upon cross-examination, while he would permit the use of the hypothetical question, he would limit it to the facts of the case which must be fairly presented in the question asked The practice of allowing on cross-examination any kind of a

hypothetical question based on a part of the facts in the case or on assumed facts not in the case he would abolish.

These criticisms are not without great force. But the solution of these difficulties is not easy. The hypothetical question grows out of the institution of trial by jury, and is a part of its warp and woof. The ultimate question of fact in issue must be determined by the jury unless we are to abolish that method of trial and substitute something else. An assumed state of facts in the form of a question for the purpose of allowing the expert to give his opinion, is the effort of the law to preserve the independent right of the jury to decide the issue of fact involved and to give them at the same time the knowledge of an expert in the matters beyond the range of their experience. If the hypothetical question is abolished, and the expert is turned loose to give his opinion on the case as a whole, none of the evils of expert testimony are avoided. He becomes also an expert on the veracity and integrity of the other witnesses. He gives his opinion, not only on the matters beyond the range of the experience of the ordinary man, but on the weight and credit of the testimony, which is peculiarly the right of the jury to pass on. The expert thereby usurps the place of the jury and decides for himself what part of the evidence in the case he believes to be true, what part is material to the formation of an opinion, what part he may see fit to regard or to disregard as not affecting his conclusion. Under the present system, when all the assumed facts forming the basis for an opinion are set forth in the question, it is possible to direct the jury's attention to those facts which are not fully proved or as to which the evidence conflicts, and to substitute another theory which other evidence tends to prove and thereby modify or control the conclusions reached by the expert. To abolish the hypothetical question, is, it seems to me, but a halfway step to the substitution of a trial by a commission of experts for a trial by jury; whether or not such a remedy would be wise is another question.

Another favorite criticism of experts is the technical jargon which many of them make use of in giving their testimony.

That they do offend in this way no one need, nor, indeed, can truthfully deny; especially is this true of medical experts. Many flagrant and amusing examples of their offending in this given. A surgeon, describing the result of a blow o horse's hoof, uses this language:

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the coronary suture into the squa
there is a fracture of the bone a
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Expert witnesses, it is urged,
function it is to make a studied argument under the guise of an oath and in the attitude of a witness, on behalf of the side which engages and pays for their services.

Unfortunately, in many cases this is true; and herein, it seems to me, lies the one grave abuse of expert testimony. This attitude of the witness is responsible for nearly all of their conduct to which exception is taken; it is responsible for the intense partisanship which so discredits the weight of their testimony, and it is the secret of the bad reputation of expert witnesses as a class.

The reasons why the expert witness is so often merely a hired advocate, are, it seems to me, first, the unlimited freedom given to each party to select and call, without limit as to number, his own expert witnesses, second, the absence of any regulation as to the amount of pay or the manner of making it.

To admit the evil and to point out the cause of it is not, however to find a remedy. Nearly all witnesses, it is true, are more or less partisans. When called and sworn on a particular side of the cause, they become more or less unconsciously interested in the outcome

and yield more or less to the temptation to help along what they are apt to regard as their side of the fight. This is a common defect of human nature with which one must reckon in the administration of justice. While neither commendable nor harmless, it is, perhaps, beyond the reach of any remedy except such as the sound common sense of a jury applies to it; unfortunately a jury is not enough to discredit testimony quite in proportion to the bias and feeling displayed by the witness.

A professional expert witness is, however, almost uniformly a conscious and intense partisan. Many of them are mere intellectual soldiers of fortune. Particularly is this true of handwriting, medical and chemical experts. The business of an expert in these branches has become profitable and a class has grown up who hold themselves ready and willing to give their services as witnesses for hire. The cases in which they are called and in which these defects are exhibited so unpleasantly often involve questions on the frontier of scientific thought as to which no final theory has been accepted. The expert is apt to come with a theory of his own which he has nursed and petted until he has for it all the fondness of paternal affection, and in which he believes as firmly as if it were a scientific truth as long established and as well accepted as the law of gravitation. Naturally, under such circumstances, all the pride and obstinacy of opinion are fully aroused.

In addition to this explainable and more or less natural partisanship, must be charged much that is due to the private right of selection, and of pay. The expert, holding himself, like the lawyer, in readiness to accept employment from the first comer who can pay the price, and who knows his services will not be needed unless his opinion coincides with that of his prospective employer, seeks to form an opinion such as is desired, and then to invent reasons in its support. When thus hired and once enlisted in the warfare, he degenerates into an advocate and no longer occupies the attitude of a witness. If a feasible remedy for this state of affairs could be invented, the cause of justice would be greatly promoted, even though such exhibitions are, it seems to me, comparatively rare in comparison with the number of cases in which resort is had to expert testimony.

A frequent recommendation is to take away from the parties their freedom of choice in selecting and calling experts, and to vest the

right of selection in the courts. Sc
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would be beyond the control of any rule of law.

Moreover, permitting the court to select the experts means, of course, that they must be called by one side or the other. It would be better to take at once the logical step of substituting trial by a commission of experts for the right of trial by jury. This has, indeed, been recommended. The practical difficulties in the way of its adoption are too great to require a serious consideration of it. In the first place, trial by jury is so much a part of the English law, and the English lawyer has been so thoroughly trained in it, that he will be found against the substitution of any other method. The expense of such a commission would be so great that the taxpayers would refuse to support and maintain it. A satisfactory and efficient personnel for a permanent commission would be impossible of attainment, and as a result special commissions would have to be organized for each particular case involving a question of expert testimony. As the required number of desirable experts on many, not to say all matters to be tried by experts, is not to be found easily, the court in impanelling the commission might have to search an entire State, or, indeed, go beyond the limits of a State, to find members. For instance, it is said that there are not more than a score of trained experts in handwriting in the entire United States. If the commis-

sion cannot be efficient, then it is not wise to substitute it for a jury. If a permanent commission for any given territory cannot be provided, then the dangers attending the selection of a special one are too great to be lightly ignored.

I prefer trial by jury in all its impaired vigor, and with all its crudities, to a trial by a court-martial, a legislative committee or a commission of experts. I think justice will be done by it more certainly and more expeditiously than by any of the proposed substitutes.

All of the proposed remedies, with the exception I have already noted, in some way or another encroach on the province of the jury as the arbiter of the facts, and substitutes the judgment of someone else, formed in some way, one knows not how, but not according to the recognized rules and methods of the law of evidence. It is for these reasons that one needs to go slow in radical efforts to root out so-called abuses in expert testimony.

The more one reflects on the subject, however, the more persuaded does one become that most of the criticism is wrongly directed. It is based upon the fact that the experts disagree, and thereby confuse the jury. But, as we have already pointed out, other witnesses disagree and thereby confuse the juries; it is because persons and witnesses disagree that courts are established and trials of issue of fact by a jury are made necessary. Lord Mansfield once said:

"As mathematical and absolute certainty is seldom to be attained in human affairs, reason and public utility require that Judges and all mankind in forming their opinions of the truth of facts should be regulated by the superior probabilities on one side or the other."

It may not be amiss to call attention to the fact that the Anglo-Saxon system of evidence has stood the test of time and experience better than any other department of the English law. The substantive law itself has changed greatly in the past two centuries and is destined to change even more in the years that are to come. Methods of pleading have been entirely changed until the time-honored system of common law pleading has been abolished in England and all her colonies and remains in force in not more than five States of the Union. But in two hundred years there has been but one important or fundamental change made in the law of evidence, and that has consisted in removing disabilities on the competency of

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ter upon which he is to testify.

Third, When on the stand t
volunteer information.

Fourth, When describing tec
guage which ordinary men can understand; otherwise much of the value of the testimony is lost and a bad impression made upon the jury.

Fifth, Never get angry at anything the opposing counsel says.

Paper No. 1154.

ANCIENT AND MODERN WATER WORKS

By EDWARD WEGMANN

Ooctber 19, 1915

Water is as necessary to life as food, and hence from the earliest times men have built works to secure an adequate water supply. In Egypt these works consisted simply of ditches which were dug for irrigation and water supply. The ruins of only one aqueduct is found in that country, viz., the conduit that supplied ancient Cairo and that is supposed to have been of Roman origin.

This aqueduct led from the Nile to the citadel of Cairo. The water was first raised by chain pumps to a height of 92 feet into a reservoir, from which it was conducted by an aqueduct, having a length of 11,925 feet and a fall of 23.43 feet. The aqueduct is above ground and carried largely by arcades for the first 8,514 feet. This part is not vaulted. For the next 2,428 feet it is underground and lined with masonry. For the last 983 feet the aqueduct is in rock tunnel. Near the end of the aqueduct three wells were sunk for raising water, with chain pumps, in three lifts, respectively 29, 59 and 130 feet.

In Asia Minor there are a number of ruins of aqueducts, some of which were constructed in a very remote period of history, and others which were built by the Romans. One of the oldest of these ruins is that of the Aqueduct of Patara which is described below.

The Aqueduct of Patara

The Aqueduct of Patara in Syria, is one of the oldest works of its kind. It was built across a ravine, which has a maximum w[illegible] of 200 feet and a depth of about 250 feet. The height of th[illegible] duct wall, built across the valley is, however, considerably l[illegible] the figure just named, as the wall is made, on both sides, by [illegible] ing inclines, only the central part being horizontal. Th[illegible]

made by the north and so
respectively 156° and 169°.

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Broken earthen pipes are
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AQUE

This aqueduct was buil
Bethlehem, known as Solomon's pools, to Jerusalem. The work has been attributed to Solomon and was probably constructed about his time, although Josephus does not mention the fact. According to descriptions given by several travelers, the aqueduct consisted of earthen pipes, about 10 inches in diameter, each pipe being encased by two stones, cut to fit. The pipes, thus strengthened, were placed on stone foundations and covered with rough stones, laid in mortar. The aqueduct, which was about 12 miles long, took a circuitous route around the hills, the whole work being generally below the surface; but, in crossing the plain at Jerusalem, the aqueduct was built mostly above ground It terminated just west of the Temple, for which the water was specially needed.

Solomon is said to have had a house and garden near the pools named after him, where the "sealed fountain," from which the conduit conveyed the water was located. The reservoirs are still in existence and remains of the aqueduct are found at many places. At one point the aqueduct was carried by a bridge across a stream.

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of Smyrna, the joints betw
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kept in place by mortar.

In Greece pipe lines sim
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(Fig. 1), built about 500 B. C.

ROMAN AQUEDUCTS

The Romans were the greatest builders of aqueducts in ancient times. Ruins of their works are to be found in many places in Europe and in Asia Minor.

The City of Rome was supplied with water in the first century of the Christian era by nine aqueducts. Sextus Julius Frontinus*, who was appointed about 97 A. D., curator aquarum—caretaker of the aqueducts, or as we would now say, Commissioner of Water Supply—wrote a detailed description of these aqueducts, which has been translated into French, German and English. We are indebted to Frontinus for most of the information we have about these nine

*Frontinus was born of a Patrician family about 35 A. D., and died in 103 A. D. He was made praetor in 70 A. D., and was three times consul. He distinguished himself as a soldier and was made governor of Britain. Prior to writing his description of the aqueducts of Rome, he had written treatises on "Surveying" and "The Art of War."

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creased. The new supply
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was called Aqua Tepula (tepid water).

The four aqueducts described above furnished Rome with an adequate water supply for ninety-two years, viz. to 33 B. C. An additional aqueduct was then required. Its supply was obtained from springs near the source of the Aqua Tepula. The new conduit, which was named the Aqua Julia, in honor of the emperor Julius Caesar Augustus, had a length of about 14 miles. For part of its length it was built on top of the Aqua Tepula. Near the walls of the city, the Marcian arches carried three aqueducts, one above the other, viz. the Marcia, Tepula and Julia (Fig. 2). The work was performed under the direction of the Aedile M. Vipsannius Agrippa.

About fourteen years later (19 B. C.), the Aedile Agrippa, who had built the Aqua Julia, brought another supply of water to the city. Springs near the Anio River formed the source of this supply. They were pointed out by a young girl (virgo) to some soldiers who were looking for water, and this circumstance gave the new aqueduct its name, viz. Aqua Virgo. The conduit was 13 miles long and was built, with the exception of one mile, below ground.

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Fig. 5. Plan of Rome

For about fifty years Rome had enough water, but by 38 A. D. the supply had again to be increased, owing to the growth of the population and the luxurious habits of the people. Two new aqueducts were built in 38-52 A. D. The work was begun during the reign of the Emperor Caligula, and was completed by the Emperor Claudius, after whom one of these conduits was called the Aqua Claudia. It derived its supply from two fine springs, lying about 38 miles from Rome. This aqueduct was about 43 miles long. For 9 miles of its length it was built above ground. Near Rome it was carried by a fine arcade, 6 miles long (Figs. 3 and 4).

The second of these aqueducts, known as the Aqua Anio Novus—the New Anio water—tapped the Anio River, about 42 miles from Rome. As the river carried much sediment after rain storms, a settling basin had to be built at the inlet of the aqueduct, but, in spite of this precaution, the water reached the city much discolored after heavy rains. This aqueduct was 54 miles long. For 9 miles of its length it was above ground—generally on top of the Claudian Aqueduct.

The principal data of the nine aqueducts described above are given in the following table:

ROMAN AQUEDUCTS, DESCRIBED BY FRONTINUS 97 A. D.

Name	Date	Length in Miles Below ground	Length in Miles Above ground	Total	Height of water above quary of Tiber in feet	No. of Castellae	Total Supply in Quinariae
Aqua Appia ...	312 B. C.	10.23	.06	10.29	27.5	20	704
Anio Vetus ...	272-269 B. C.	39.33	.30	39.53	82.6	35	1610
Marcia	144-140 B. C.	49.87	6.86	56.73	123.0	51	1935
Tepula	125 B. C.	5.51	6.44	11.95	125.4	14	445
Julia	33 B. C.	7.75	6.44	14.19	130.3	17	803
Virgo	19 B. C.	11.83	1.14	12.97	34.2	18	2504
Alsietinus	10 B. C.	19.96	.33	20.29			392
Claudia	38-52 A. D.	33.31					
			9.35	42.66	155.6	92	5625
Anio Novus ..	38-52 A. D.	45.32	8.64	53.96	155.6		
Total		223.11	39.46	262.57		247	14,018

Some additional aqueducts and branch conduits were built subsequent to Frontinus' time. The principal of these works are mentioned below.

The Aqua Trajana was built in 109 A. D. by the Emperor Trajan to bring water from springs north of Lake Sabatinus (now Lago di Bracciano) into the city. At a later period this aqueduct drew water direct from the lake.

The Aqua Hadriana was built in 120 A. D. by the Emperor Hadrian. Originally this aqueduct brought water only to the great villa of the emperor, near Cento Celli, about 5 miles from Rome. About 226 A. D. it was extended to Rome.

The Aqua Aurelia was built by Marcus Aurelius in 185 A. D. to convey water from springs near Mariano to his villa on the Via Appia This aqueduct was extended in 196 A. D. to Rome by Septi Severus, after whom the conduit was then named Aqua Severi

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and of cooling it suddenly
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occur about once every half
ever, that these angles were
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At each of these angles a
occasionally a settling basin (piscina). These reservoirs served as points of distribution of the water, and, also, as blow-offs. Each settling basin had two upper and two lower chambers. The water entered the first upper chamber and passed down, probably through a pipe, to the first lower chamber. It then passed through numerous small holes into the second lower chamber, and rose through a hole in the roof of this chamber to the second upper chamber. In following this circuitous path, the water left most of the sediment it carried in the lower chambers. When these chambers had to be cleaned, the water could be shut off from the lower chambers by means of suitable sluices, and would flow then directly from the first upper chamber to the second one.

Ventilators (luminae) were built at frequent intervals along the line end of each aqueduct. They were provided with steps which gave access to the aqueduct, and served sometimes as wells, where water could be drawn out of the aqueduct by means of buckets.

Distribution of Water

The aqueducts terminated in the city in large reservoirs (castella

publica), some of which received the water of several conduits. By means of lead pipes, water was conveyed from these reservoirs to smaller reservoirs or cisterns, (castella privata) each of which was usually built by several consumers, who clubbed together for this purpose. From these cisterns the water was taken, usually in lead pipes, to the domestic cisterns in the courtyards of the houses. In the time of Frontinus there were 247 public and private reservoirs in Rome. Ruins of many of them are still to be seen.

The service pipes (Fig. 8) were usually made of lead and given a piriform shape. Each pipe was uniformly 10 Roman feet (9.8 English feet) long. It was made of sheet lead, about ¼ inch thick, which was bent to the proper shape. The longitudinal joint on top of the pipe was made by forming a channel by means of clay on each side of the joint, and filling the channel with molten lead, a mixture of different kinds being used. The name of the contractor, who laid the pipe, and usually also of the owner, was stamped on the pipe.

Consumption of Water

Upon assuming charge of the water works of Rome, Frontinus made a careful inspection of each of the nine aqueducts, and gauged its capacity. Unfortunately, he simply measured the wetted area of each water channel and paid no attention to the velocity of the water. By dividing the wetted area of each aqueduct by the area of a standard pipe, called a quinaria, he obtained the number of pipes the aqueduct would supply. Here again he made a serious mistake, as the friction in a water pipe depends on its hydraulic radius, which is the wetted area, divided by the wetted perimeter. In flowing through a number of small pipes, a certain quantity of water encounters more friction than in passing through one large pipe. Frontinus gives us the capacity of each aqueduct, determined by his faulty method, in an equivalent number of quainariae, the area of each being 0.632 square inches, about equal to that of a circle 0.9 inches in diameter.

Based upon erroneous assumptions, a French engineer, M. delet, computed the discharge of a quinaria pipe to be U. S. gallons in 24 hours. By multiplying the number of given by Frontinus as the capacity of the nine aqueducts of

permitted to sell all the water that leaked from the conduits. When a leak occurred these men were prone to encourage it, instead of trying to stop it.

Another peculiar law obliged the Commissioner of Water Supply to give only one quarter of his time to his public duties. It appears that some of these commissioners took public contracts on which they employed the men who were supposed to take care of the aqueducts.

Frontinus tells us that, at times, two or three of the nine aqueducts did not deliver a drop of water into the city. This was partly due to their leaky condition, and partly to the fact that rich and influential people diverted the water to their villas, before it could reach the city.

Roman Aqueducts in Various Places

Wherever the Romans founded a city, one of the first works they undertook was the construction of an aqueduct for obtaining an adequate supply of pure and wholesome water. More than two hundred ruins of Roman aqueducts are to be found in various parts of Europe and Asia Minor. A brief mention of some of the most important of these works is given below.

The Aqueduct of Nismes

in the southern part of France, was built in the first century of the Christian Era to bring a water supply to the city of Nemausis (now Nismes). It was about 30 miles long and had a general grade of about 3 feet per mile. Its water channel was generally about 4 feet wide by 5 feet high, but in tunnels the height was increased to 7½ feet.

The most remarkable part of this aqueduct is the crossing of the deep valley of the river Gard, about midway between the springs that furnish the water supply and the terminus of the aqueduct. This crossing was effected by means of an arcade, about 160 feet high, known now as the Pont du Gard (Fig. 9) which is still in an excellent state of preservation. The arcade is composed of three tiers of semi-circular arches. The lowest tier contains six arches: one of 80 feet span, three of 51 feet span and two of 51 feet sp
The second tier contains eleven arches, each of 51 feet span.

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THE AQUEDUCT OF METZ, FRANCE

Ruins of an important Roman aqueduct are found near Metz. The date of its construction is unknown, but the work is supposed to have been built during the first century of the Christian era. The aqueduct had a length of about 15 miles and a total fall of about 73 feet. Its section was 3 feet wide by 6 1-3 feet high, the top being rounded. The aqueduct was built in a similar manner as those of Lyons, but had no siphons. One of its arcades had a length of about 3,600 feet and a maximum height of about 100 feet. In this aqueduct the conduit on the arcades was divided by a central wall into two water channels, one of which could be kept in service, while the other was being cleaned or repaired. The aqueduct crossed the river Moselle on a high arcade of one range of arches, at a point about two leagues from Metz, where the stream has considerable width. Out of 118 arches of this arcade, five are still standing perfectly solid.

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Spain, had an arcade 876 fee

WATER SUP

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The Acqua Felice was buil (Felice Peretti) after whom from springs that furnished w

THE ACQUA PAOLA

About 1618 Pope Paul V restored the old Trajana to use. It is named after him the Acqua Paola.

THE ACQUA PIA

was constructed by a private company in 1860-1870 to introduce into Rome again the excellent spring water that had supplied the Aqua Marcia. This conduit was named after Pope Pius IX, who took a lively interest in this work, the Acqua Pia.

The four aqueducts described above furnish the water supply of Modern Rome. Their lengths, capacities, etc., are given by Rodolfo Lanciani in his "Ruins and Excavations of Ancient Rome," as follows:

WATER SUPPLY OF MODERN ROME

Aqueduct	Date	Author	Lengths in meters	Delivery in 24 hours in cubic meters
Vergine ..	1570	Pope Pius V	20,546	155,271
Felice .	.1587	Pope Sixtus V	32,593	21,634
Paola	1611	Pope Paul V	51.852	80.870
Pia	1870	Societa dell-aequa	53.649	121,306

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works were authorized by the Legislature in 1834, and were constructed in 1837 to 1842. A dam, about 50 feet high, was built across the Croton River to form a "fountain reservoir," and the water was conveyed by a masonry aqueduct, 38 miles long, from this reservoir to a receiving reservoir, constructed on land which now forms part of Central Park. Three 36-inch water mains conveyed the water from the receiving reservoir to a distributing reservoir on Murray Hill, at Fifth Avenue and 42nd Street. The total length of the aqueduct and pipe line is 40½ miles.

The aqueduct is 8 feet 5½ inches high and 7 feet 5 inches wide at the spring line of the arch. According to the original plans, it was only to be filled to the spring line of the arch, at which level its capacity was estimated at 36,000,000 gallons for 24 hours. Owing to the rapid increase in consumption, the water level in the aqueduct was raised by 1889 to the crown of the arch, and the discharge was increased thereby to about 95,000,000 gallons per 24 hours.

One of the finest structures on the line of the Croton aqueduct—now called the Old Croton Aqueduct, in order to distinguish it from

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One of the finest structures on the line of the Croton aqueduct—now called the Old Croton Aqueduct, in order to distinguish it from

a later conduit, named New Croton Aqueduct—is High Bridge, (Fig. 13) a fine bridge across the Harlem River, which is 100 feet high from high-water to the crown of the arches. Three pipes, placed in a vault, two of 36 inches diameter, and one of 90½ inches diameter, convey the Croton water across the bridge.

The first Croton water was introduced into New York on July 4, 1842. The total cost of the Old Croton Aqueduct and reservoirs was about $9,000,000.

Owing to the wonderful growth of New York, additional reservoirs had soon to be constructed in the Croton water shed, to store the excess of water during floods for periods of drought.

A list of these reservoirs, built to date, is given in the following table:

STORAGE RESERVOIRS IN THE CROTON WATER SHED

Name of Reservoir	Put in Service	Capacity in gallons
Old Croton Lake	1842	
Boyd's Corners	1873	2,727,000,000
Middle Branch	1878	4,155,000,000
East Branch (Sodom)	1891	5,243,000,000
Bog Brook	1891	4,400,000,000
Titicus	1893	7,617,000,000
West Branch (Carmel)	1895	10,668,000,000
Amawalk	1897	7,086,000,000
New Croton	1905	33,815,000,000
Cross River	1908	10,923,000,000
Croton Falls	1911	15,753,000,000
Total		102,387,000,000

In addition to the above reservoirs, the city owns a number of small lakes and ponds from which it can draw about 2,810,000,000 gallons. Including these lakes and ponds, the total available storage in the Croton watershed amounts to 105,197,000,000 gallons.

By 1875 the Old Croton Aqueduct was strained to its utmost capacity to supply the consumption of water in New York. The construction of a second aqueduct from the Croton Valley to the city was urged, but the work could not be undertaken, owing to the deplorable condition of the city's finances, resulting from mismanagement.

A small additional supply of about 22,000,000 gallons per day was obtained in 1884 to 1890 from the Bronx and Byram rivers, and conveyed in a 48-inch pipe line to a receiving reservoir, constructed at Williams bridge in the present borough of the Bronx.

feet; Third, a pipe line, 2.37 miles long, consisting of eight lines of 48-inch cast iron mains. The total length of the aqueduct from Croton Lake to the receiving reservoir in Central Park is 33.12 miles.

The New Croton Aqueduct was constructed entirely in tunnel, with the exception of a few short stretches, aggregating 1.12 miles, where the conduit was built in open trenches, and with the exception of the pipe line. The conduit begins at a large inlet gate house, built at Croton Lake, and terminates at a gate house at 135th Street and Convent Avenue, at which the pipe lines begin.

A large receiving reservoir, known as the Jerome Park Reservoir, was to be built in the borough of the Bronx. It was to have two basins, storing together about 1,900,000,000 gallons. The westerly basin, having a capacity of about 800,000,000 gallons, has been completed, but work on the easterly basin was stopped about 1903, as the construction of a filter was contemplated on the ground the basin was to occupy.

Under the direction of the Aqueduct Commissioners seven large storage reservoirs were built in the Croton watershed. Their capacities are given on page 343. The most important of these basins is the New Croton Reservoir, which was formed by building a high masonry dam, known as the New Croton Dam, across the Croton Valley, about three miles below the Old Croton Dam.

The New Croton Dam (Figs. 14 and 15) was built in 1895 to 1907. It has a length of crest of about 2,200 feet including the spillway, which is built along the north side of the valley, almost at right angles to the main dam. The maximum height of the dam, from the lowest point in the foundation to the crest of the dam, is 297 feet. The high water mark in the reservoir formed by this dam is 30 feet higher than the high water mark of the Old Croton Reservoir. The cost of the New Croton Dam, including the construction of new highways, etc., amounted to about $7,600,000.

The Catskill Water Supply

The minimum yield of the Croton water shed, with the storage reservoirs, lakes and ponds mentioned on page 343, is estimated at about 290,000,000 gallons a day. The boroughs of Manhattan and the Bronx were consuming more than this quantity of water by 1905,

and the other three boroughs of
Queens and Richmond) were sho
sary to secure, without delay, an
York.

In 1902 a commission of eng
Burr, Rudolf Hering and John
report on the best way of increa
to the Commissioner of Water
commission recommended that
gallons be obtained from streams in Dutchess County, immediately north of the Croton water shed, and an equal quantity from water sheds in the Catskill mountains. A law, passed by the State Legislature in 1904, prohibited the City of New York from diverting water from Dutchess County, and the city was, therefore, obliged to secure its whole additional supply from the Catskill water shed. In 1905 an act was passed that gave the city the necessary authority to obtain this supply. The construction of the necessary works was entrusted to a Board of Water Supply, composed of three members, which was organized in the summer of 1905. J. Waldo Smith was appointed chief engineer of this commission, and John R. Freeman, Prof. William H. Burr and Frederick P. Stearns were retained as consulting engineers. The construction of the works was begun in 1906 and will be practically completed by the end of 1915.

Figs. 16, 17 and 18 show the general plan of the Catskill water works. The supply is to be secured from four principal water sheds in the Catskill mountains, which will yield together with some small contiguous water sheds a minimum supply of about 900,000,000 gallons per day. Thus far, works have only been built on one of these streams, viz., on Esopus Creek, on which a storage reservoir having an available capacity of 128,000,000,000 gallons has been constructed. This basin, known as the Ashokan Reservoir, has been formed by the construction of a masonry dam, which is flanked on both sides by earth dams, aggregating 3,650 feet in length. The masonry part of this structure, known as the Olive Bridge Dam, is 1,000 feet long and has a maximum height of 240 feet above the foundation of Esopus Creek. The water shed above the Ashokan dam contains 255 square miles and is capable of furnishing a minimum daily supply of 250,000,000 gallons

From the Ashokan Reservoir the water is to be conveyed to the City of New York by an aqueduct having a capacity of 500,000,000 gallons per day. This aqueduct, which is 92 miles long, terminates at the Hill View Reservoir, an equalizing reservoir of 900,000,000 gallons capacity, constructed on high ground at the north boundary of New York. The Catskill Aqueduct was constructed according to four types, which are shown in Fig. 19, as follows:

CATSKILL AQUEDUCT.

Cut-and-cover	55 miles
Grade tunnel	14 miles
Pressure tunnel	17 miles
Siphon pipes	6 miles
Total	92 miles

The dimensions of the different types of aqueduct are given in Fig. 19. Each siphon is to consist eventually of three lines of steel pipes, of which only one has thus far been laid. The steel pipes are lined on the inside with two inches of cement mortar, enveloped with concrete and covered with an earth embankment.

A large storage basin, known as the Kensico Reservoir, is being constructed on the line of the Catskill Aqueduct, about 15 miles north of the Hill View Reservoir. It has an available capacity of about 29,000,000,000 gallons, and will be able to supply the city with water for several months, in case the supply from the Ashokan Reservoir should be interrupted. The Kensico Reservoir is formed by a masonry dam, 1,850 feet long, having a maximum height of 310 feet above the lowest point of the foundation.

From the Hill View Reservoir, the water will be delivered to the five boroughs of the city by a circular tunnel, 18 miles long, driven through solid rock, 200-750 feet deep below the street surface (Fig. 17). The diameter of the tunnel is 15 feet at the Hill View Reservoir and is gradually reduced to 11 feet diameter at its terminus in Brooklyn. From two terminal shafts in Brooklyn, steel and iron pipe lines extend into the borough of Queens and Richmond. The supply to the latter borough is conveyed across the Narrows to Staten Island in a 36-inch flexible jointed, cast iron pipe, which was

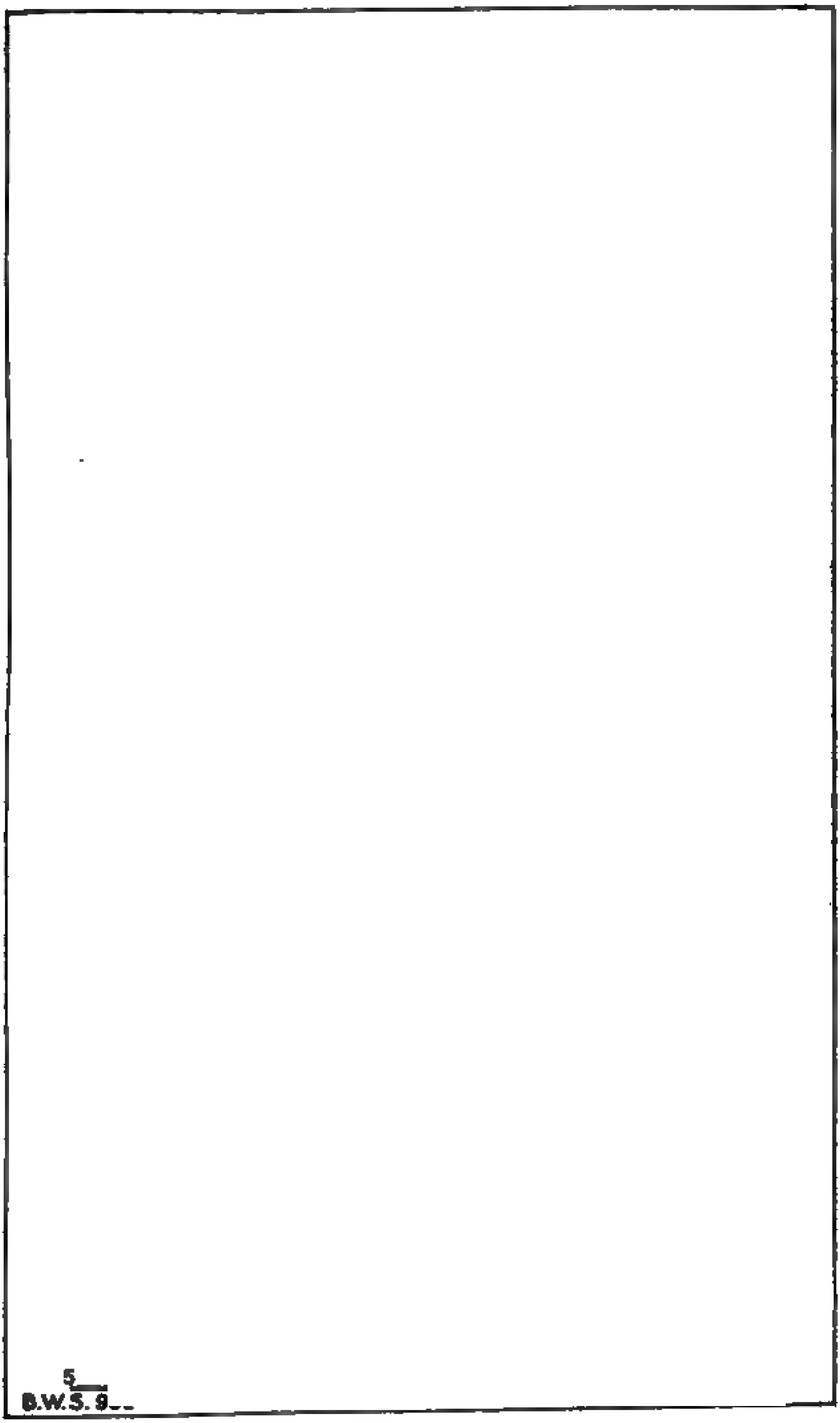
buried in a trench in the harbor b
Staten Island by 48-inch mains to
stores 435,000,000 gallons. The to
tem, including tunnels and pipe li
From the short description giver
of the magnitude of the great wate
The growth of this city and th
water is shown in the following table:

POPULATION OF THE CITY OF NEW YORK

Year.	Population.	Water Consumption
1790	33,131	....
1800	60,515	....
1810	96,373	....
1820	123,706	....
1830	202,589	....
1840	312,710	....
1850	515,547	40,000,000
1860	813,669	....
1870	942,292	77,000,000
1880	1,206,299	92,000,000
1890	1,515,301	145,000,000
1900	3,437,202	470,000,000
1910	4,766,883	500,000,000

*In 1898, Brooklyn, part of Queens County, and Staten Island were added to the City under the Charter of the Greater New York. This accounts for the large increase in population and water consumption at that time.

We have glanced now briefly at the greatest water works of ancient and of modern times. While the latter surpasses the former in magnitude and importance, the works constructed in ancient times with very primitive means and imperfect instruments excite the admiration of the modern engineer.



Catskill watersheds and aqueduct

Fig. 16.—Plan of the Catskill Aqueduct.

resigning to become Resident Director of the mining interests of Madeira, Hill and Company, establishing his headquarters in Pottsville. It was this position he held at the time of his death.

In October, 1893, Mr. Hill was united in marriage with Miss Alice Marie Muller, of Joliet, Illinois. To this union were born three children: Frank, Marie and Alexandria, who with his widow and sister survive him.

The funeral services, held at his late residence upon Friday afternoon, July 16th, were attended by prominent coal men from all parts of the Eastern United States. Interment was made in a plot recently selected by himself in the Charles Baber Cemetery, at Pottsville.

In the death of Mr. Hill the coal industry, as well as his friends, whom he numbered by the thousands, have met with a severe loss.

RICHARD W. GILPIN

Richard W. Gilpin, whose death occurred on June 21st, 1915, after a short illness, while at Cape May, N. J., where he had gone in the hope of regaining his health, was born near West Chester, Chester County, Pa., and received an academic education in the Episcopal Academy, Philadelphia, Pa.

His early fondness for scientific matters prompted his entering the employment of the Weston Electrical Co., of Newark, N. J., where he devoted all his time to the study of electrical engineering. After spending four years in the Weston electrical plant he entered the service of the United States Lighting Co. in New York, who were pioneers in the development of electrical house and street lighting in New York and other cities.

He established an office as Consulting Electrical Engineer in 1895 at 505 Chestnut Street, Philadelphia. In his capacity as Consulting Engineer he was a designer as well as adviser in the electrical heating and lighting equipment of many public buildings and private residences in Philadelphia and vicinity; notably, Academy of Fine Arts, Horticultural Hall, College of Physicians, Blind Asylum, Overbrook, Pa., a number of the Philadelphia Public Libraries and Princeton University.

At the time of his death he was a vestryman in the Church of the Ascension, a life member of the Franklin Institute, member of the Philobiblon Club, City Club, Pennsylvania Forestry Association and National Geographic Society. He was elected a member of the Engineers Club of Philadelphia in May 18, 1895.

Mr. Gilpin was at all times a most earnest advocate of a civic uplift in public affairs and did yeoman service as a member of the Seventh Ward Improvement Association.

TEILE HENRY MULLER

Teile Henry Muller—Born January 18th, 1841, at Grossensiel-Oldenburg, Germany. School in Oldenburg until 1857. Polytechnic School at Hannover 1858 to 1862. Ship engineer with North German Lloyd and English line to Africa. Located in New York in 1864 as draughtsman and machinist with the Root Steam Engine Co., in 1868 as Superintendent of the Convex Weaving Co., built their mill and designed and built the machinery. Went to the Eagle Pencil Co. to re-design machinery and revise process for manufacturing pencils, penholders, etc. In 1872 employed by Wm. Farmer as gas works engineer.

Designed the changes for the Sugar Refinery of Durand & Sons and from there, in 1877, went to S. S. Hepworth & Co., builders of sugar machinery. Designed the California Sugar Refinery in San Francisco for Mr. Claus Spreckles and the Belchers Refinery in St. Louis. Among the plantations fitted up complete was the "Cayalty" in Peru. In 1887 moved to Philadelphia and opened an office as consulting engineer. Designed and built the "Spreckles" Refinery, after a completion of which he designed for the Newhall Engineering Co., the National Sugar Refinery in Yonkers, for Mr. G. R. Bunker and supervised work in their office, the building of their sugar houses and machinery. Designed and partly built the Camden Sugar Refinery. Broke down from overwork and went to Europe in 1896 for the summer and returned to New York in 1897, where he was occupied mostly with the ice factories, until 1900, when he engaged with the Federal Sugar Refinery Co., as constructing engineer, and designed and built their works in Yonkers, died, September 20, 1915.

ABSTRACT OF MINUTES OF THE CLUB

REGULAR MEETING, JUNE 6, 1915

The meeting was called to order by President Ledoux, at 8.40 P. M., with forty-five members and visitors in attendance.

The minutes of the regular meeting of the Club held May 15th, 1915, were approved as printed in abstract.

Mr. W. Copeland Furber presented the paper of the evening, entitled "Modern School House Construction," which was discussed by Mrs. Edith Pierce, Mrs. Edw. Gryce and Dr. J. Madison Taylor. Meeting adjourned at 10.30 P. M.

REGULAR MEETING, SEPTEMBER 14, 1915

The meeting was called to order by President Ledoux at 8.30 P. M., with 75 members and visitors in attendance. The minutes of the meeting of June 6, 1915, were approved as printed in abstract.

The Secretary announced that at the Regular Meeting of the Board of Directors, the following had been elected: To Active Membership, Thomas H. Addie, Walter Blackson, J. Arthur Durst, H. Bayard Hodge, Richard S. Newbold, William E. Thomas, Henry C. Wright and Frederick James Ryan; to Junior Membership, Harry I. Goldstein. The Secretary also announced that T. Elmer Moon, member of the Illuminating Engineering Society, had been enrolled as an Active Member, in accordance with Article VI, Section 1, of the By-Laws.

The Secretary announced that the Board of Directors had submitted the names of the following men to constitute the Committee on Nominations for the ensuing year:

Robert H. Fernald, Chairman; John C. Trautwine, Jr., H. E. Ehlers, H. H. Quimby, R. G. Develin, Bruce Ford, W. C. Kerr.

Alternates: A. C. Vauclain, Charles F. Mebus and W. H. Fulweiler.

In accordance with Article V, Section 2, of the By-Laws, this list will be submitted to the Club at the October meeting for alteration or acceptance.

Mr. C. E. Drayer, of the Cleveland Engineering Society, presented the paper of the evening, entitled "Engineering Societies and Publicity," which was discussed by Messrs. John C. Trautwine, Jr., W. Copeland Furber, Morris L. Cooke, Frank L. Neal, P. A. Maignen, Prof. Robert H. Fernald and Dr. H. M. Chance.

ABSTRACT OF MINUTES
OF THE
BOARD OF DIRECTORS

REGULAR MEETING, SEPTEMBER 14, 1915

Present: Vice-President Snook, with Vice-Presidents Vogleson and Yarnall, Directors Hibbs, Wagner, Dauner, Moore, Bonine, Irish, Jones, Humphrey, Hess, Taylor the Secretary and the Treasurer in attendance. President Ledoux and Past President Swaab were excused. Directors Gibson, Worley, Andrews, Dunlap, Wilson, Tracy, Hornor and Davis were absent.

The minutes of the Regular Meeting of June 15th were read and approved. The minutes of the Special Meeting of July 19th were amended as follows:

"As no quorum was present, no official business was transacted, but the following opinion of the members present was expressed:

That we, members of the Board of Directors of the Engineers' Club, of Philadelphia, deem it advisable that the State Public Service Commission include an engineer of standing."

It was moved and carried that the Board ratify the action of the meeting of July 19th.

The President presented an analysis of the financial condition of the Club which, on motion, was referred to the Finance Committee with instructions that they examine it and submit a report at the Adjourned Meeting to be held September 21st.

The Treasurer reported a net loss of $548.99 as compared to a net loss of $202.45 for a corresponding period of 1914.

The Membership Committee's report was presented and the following elected:

To Active Membership: Thomas H. Addie, Walter Blackson, H. Bayard Hodge, Richard S. Newbold, William E. Thomas, Henry C. Wright, J. Arthur Durst.

To Junior Membership: Harry I. Goldstein.

Mr. Yarnall, Chairman of the Committee on Increase of Membership, stated that he had telegraphed the firm of Whitslar & Wells, Cleveland, Ohio, in regard to their terms to assist in conducting our campaign for increase of membership. Mr. Yarnall was authorized to confer with a

representative of this firm and submit a report to the Board at its Adjourned Meeting to be held September 21st.

A communication from the Engineers' Society of Northeastern Pennsylvania, requesting that our Club endorse the appointment of Mr. Charles Enzian as a member of the State Public Service Commission, was presented to the Board. The Secretary was instructed to notify the Society that the Club had urged the appointment of an engineer as a member of the Public Service Commission, but it did not at this time desire to endorse any candidate. The Secretary was instructed to communicate with Governor Brumbaugh to inform him that the Club would submit names of engineers for appointment as members of the Public Service Commission, if the Governor desired it.

A letter from Mr. F. H. Newell, Chairman of the Committee on Engineering Co-operation, was presented to the Board. Messrs. Yarnall and Hess presented a report of the meeting on Engineering Co-operation held in Buffalo June 23rd and 24th. The Secretary was instructed to forward Mr. Newell a copy of our pamphlet on "Engineering Fellowship" and inform him that we are in hearty sympathy with the proposed movement, and, furthermore, that by the affiliation of local sections of national engineering societies with the Club, the engineering co-operative movement is being developed in Philadelphia.

The deaths of Richard Gilpin (June 21st, 1915), and Frank Hill were announced.

In accordance with our By-Laws, Article V, Section 2, the names of seven members to constitute a Committee on Nominations for the coming year must be submitted by the Board of Directors to the Club at its September meeting. After some discussion as to the composition of the Committee on Nominations, the chair was authorized to appoint a committee of five men, who will submit to the Board at its adjourned meeting to be held September 21st a list of not less than ten names of men who are eligible for appointment on the Committee on Nominations. The chair appointed the following:

W. P. Taylor, D. Robert Yarnall, Henry Hess, Charles E. Bonine, Richard L. Humphrey.

The Chair was authorized to appoint a committee to thoroughly index the By-Laws.

A letter was read to the Board from the Engineers' Society of Pennsylvania, stating that they had cancelled their proposed excursion to Philadelphia.

The meeting adjourned at 9.45 P. M. to meet again on Tuesday, September 21st, at 7.00 P. M.

Adjourned Meeting, September 21, 1915

Present: President Ledoux, Vice-Presidents Yarnall and Vogleson, Directors Irish, Gibson, Worley, Wagner, Bonine, Jones, Moore, Dunlap, Humphrey and Dauner, Past Presidents Hess and Taylor, the Secretary

and the Treasurer in attendance. Vice-President Snook was excused. Past President Swaab and Directors Hibbs, Andrews, Wilson, Sanville, Hornor and Davis were absent.

The minutes of the regular meeting of September 14th were read and approved.

The Committee on Nominations presented its report, and the Board directed that the following names be submitted to the club in accordance with the provisions of the By-Laws, Article V, Section 2, to constitute a Committee on Nominations for the current year:

Robert H. Fernald, Chairman; John C. Trautwine, Jr., H. E. Ehlers, H. H. Quimby, R. G. Develin, Bruce Ford, William C. Kerr.

Alternates: A. C. Vauclain, Charles F. Mebus, W. H. Fulweiler.

The Secretary announced that T. Elmer Moon, member in good standing of the I. E. S., had been enrolled as an Active Member of the Club, in accordance with Article VI, Section 1, of the By-Laws.

Upon recommendation of the Membership Committee, Frederick James Ryan was elected to Active Membership.

Percy H. Wilson was reinstated to Active Membership as of March 17th, 1913.

Appropriation of $21.00 to list the affiliated societies in the telephone directories was authorized.

Communications were received from the A. I. E. E. and the I. E. S. regarding the payment of dues for members of these affiliated societies. A motion was made and carried that the list of members submitted by the Secretary of these societies, as of April 1st, should constitute the official list on which they would pay membership dues during the Club fiscal year.

Communication from the Engineers' Society of Western Pennsylvania relative to submission of names of engineers who might be eligible for appointment as members of the Public Service Commission was ordered to be tabled until the next regular meeting of the Board.

Messrs. Hess and Yarnall spoke regarding the work of the Increase of Membership Committee, and the following motion was passed:

That the Increase of Membership Committee be authorized to enter into an agreement with the firm of Whitslar and Wells, of Cleveland, Ohio. terms not to exceed five per cent. of the dues received from new members in their first year as stipulated in our By-Laws, and that the committee be authorized to expend an amount not exceeding $1000 for the expenses of the Increase of Membership Campaign, and that the committee be given full power to act.

The meeting adjourned at 8.30 to convene at 9.30. The Board reconvened at 9.30 to discuss the report of the Finance Committee. The following recommendation of the Finance Committee was approved by the Board and ordered to be placed in its regular order of business:

The Finance Committee has come to the definite conclusion that much of its difficulty, as well as the difficulties of the various committees and of the Board with relation to the finances and the proper appropriation of the Club's income is due to the improper timing of the making up of budgets and their submission. At the meeting of the Finance Committee of March 16th, 1915, this was touched upon, and the recommendation then made to the Board the Finance Committee now presents more in detail.

For instance, the Finance Committee, at its meeting of March 16th, was supposed to make recommendations to the Board for its budget, and did not then have any knowledge or recommendations from the various committees as to their needs and a report had to be submitted to the Board March 16th. Manifestly, it was totally impossible for the Finance Committee to present to the Board within two days a properly digested report.

It is therefore recommended that each committee have its report prepared for the Finance Committee on March 1st at the latest, and that the Finance Committee submit its report in turn to the Board at its April meeting. This will result in each committee's working out its report and a budget, after it has had almost a year's experience, and in the Finance Committee's working out its report and budget after having had, similarly, almost a year's experience. In that way the Finance Committee's report goes to the Board with its almost full year of experience, and it can act on the similarly full year's experience of the Committees and Finance Committee. Under the present plan, each committee, the Finance Committee and the Board had to take action without any previous experience to guide it, so far as the committees and Board as a whole are concerned. Under this plan, the Finance Committee has six weeks in which to consider the various committee reports and to confer, possibly, several times with those committees. The Board has then two meetings in which it can consider the Finance Committee's report and translate it into action. The intervening month thus gives the Board ample opportunity for further detail conference with the Finance Committee. The whole plan would be of distinct advantage to an incoming Board, since it would not at the outset be confronted with the most difficult work that it has to deal with, i. e., the Club's budget, but would, in turn, have to deal with it as before stated, after having had practically a year's experience.

The Board approved the recommendation of the Finance Committee that the Club negotiate a loan for $5000 and authorized the issuing of notes to this amount for six months at six per cent., $1000 of this amount to be set aside to defray the expenses of the Increase of Membership Campaign. It was considered desirable that this loan be raised within the Board.

The Board ordered that the note issue be cancelled by the Club at the earliest practicable date, the order of payment being first, the $250 notes; second, the $500 notes and, finally, the $1000 notes.

The Board, on recommendation by the Finance Committee, authorized the Treasurer to transfer all of the accounts of the Club, excepting the second mortgage bond interest account, from the Colonial Trust Company to either the Franklin National Bank or the Third National Bank, preference to be given the bank which offered the better terms.

REGULAR MEETING, OCTOBER 12, 1915

Present: Vice-President Vogelson and Yarnall, Directors Gibson, Wagner, Andrews, Irish, Crampton, Humphrey, Past Presidents Swaab and Taylor and the Secretary in attendance. President Ledoux and Director Moore were excused. Vice-President Snook, Directors Hibbs, Worley, Dauner, Dunlap, Bonine, Jones, Wilson, Tracy, Davis, Past President Hess and the Treasurer were absent.

As no quorum was present, the reading of the minutes of the September 21st meeting was dispensed with. The members present decided to act upon those matters which required immediate action, and leave the ratification of the actions to a subsequent meeting of the Board.

The Treasurer's report was presented and approved.

The Secretary presented a communication from James Logan and was instructed to transmit to him the By-Laws covering the question of dues raised in his letter.

The Secretary announced that the members elected by the Board of Directors to constitute the Committee on Nominations had accepted their appointment.

Exchange of privileges with the Engineers' Club, of Kansas City, was authorized by the Board.

The Secretary was instructed to communicate with the Engineers' Society of Western Pennsylvania, asking them to notify the Engineers' Club as to the nature of the Governor's reply to their letter of September 18th.

The Secretary announced that Dr. G. S. Crampton had been appointed vice H. A. Hornor (I. E. S.) and Joseph Tracy vice H. F. Sanville (A. I. E. E.), members of the Board of Directors.

The Membership Committee's report was presented, and the following elected to Active Membership: Robert Mann Barr, Carl G. A. Schmidt, Jr.

INDEX VOLUME XXXII*

* The July issue of 1915 was numbered Vol. XXXI, No. 3, and should have been numbered Vol. XXXII, No. 3.